Draft Little River Watershed TMDL

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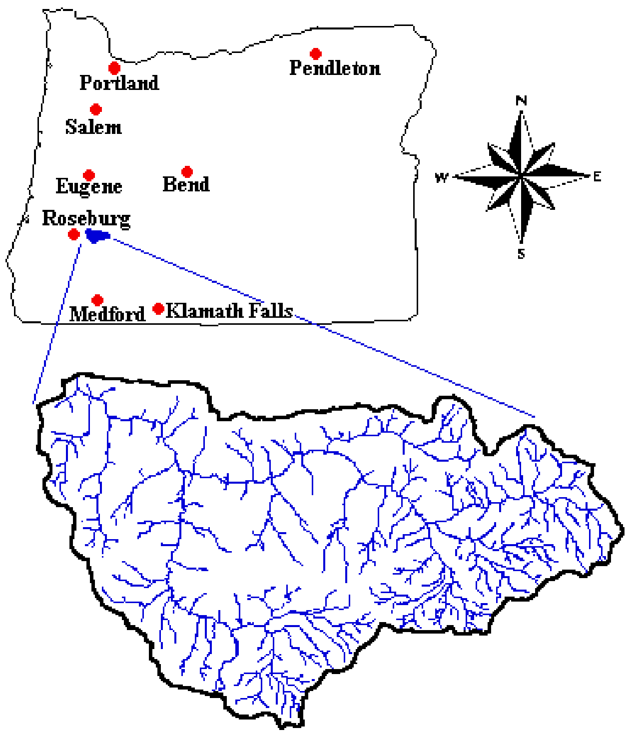

DEQ
State of Oregon
Department of
Environmental
Quality

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires that a list be developed of all impaired or threatened waters within each state. This list is called the 303(d) list after the section of the CWA that requires it. In Oregon, the Oregon Department of Environmental Quality (ODEQ) is responsible for this work. Section 303(d) also requires that the state establish a Total Maximum Daily Load (TMDL) for any waterbody designated as water quality limited (with a few exceptions, such as in cases where violations are due to natural causes). TMDLs are written plans and analyses established to ensure that waterbodies will attain and maintain water quality standards. The Little River watershed has stream segments listed on the 1998 Oregon 303(d) List for: temperature, pH, sediment, and habitat modification.

TMDLs are proposed for three of the four listed parameters, temperature, pH, and sediment. The TMDLs are applicable to all perennial streams in the Little River watershed. Habitat modification concerns will be addressed in management plans to be developed by designated management agencies (DMAs). As they are not pollutants, TMDLs will not be developed for habitat modification.

Temperature: Load allocations (LAs) for nonpoint sources are based on percent effective shade. Solar radiation has been shown to be the primary human-influenced temperature control. Percent effective shade is the most straightforward parameter to monitor and measure. It is also easily translated into quantifiable water management objectives. Results of simulation modeling using the system potential conditions for effective shading found that not all tributaries or the mainstem are likely to achieve the temperature water quality criterion of 64 degrees F. System potential shading varies depending on stream width, stream orientation and type of vegetation typically found in the region. In the tributaries, the potential effective shading ranges from 84% to 91%. Along the mainstem of Little River, the potential effective shading ranges from 75% to 99%.

There is only one point source discharging to the watershed, at the Wolf Creek Conservation Center. A load allocation in the form of a limit on the maximum temperature of the effluent has been developed. The facility's effluent temperatures have always been less than the limit of the load allocation.

pH: Assessment of the possible causes of high pH in the Little River watershed revealed that nutrient levels are below detection levels at most monitoring locations. The pH problem results from the photosynthetic activity of benthic algae, which are dependent on sunlight and warmth for growth. A strong correlation exists between elevated pH values and stream temperature. Water quality standard attainment for pH is achievable by reducing temperatures. Therefore, load allocations for pH apply the temperature TMDL allocations of percent effective shade, because of the relationship between stream temperature and pH.

Sediment: Sediment delivered to the stream channel above background conditions is attributed mainly to mid-1900's land management practices related to forest harvest in upland and riparian areas and roads utilized to gain access to these areas. The calculated rate of sediment delivery to the stream channel, measured in tons per square mile per year, shows signs of reduction since the most aggressive timber harvest and road building. A load attributed to land management activities has been identified and should be achieved, over time, through hydrologic recovery, controlled management activities in sensitive areas and treatments. TMDL implementation is expected to restore beneficial uses by salmonids and aquatic insects. Load allocations for sediment are expressed in tons of sediment per square mile per year.

Periodic water quality monitoring and use of instream numeric targets will indicate if management actions are attaining desired goals.

Water Quality Management Plan (WQMP): To address these TMDLs, a WQMP has been developed focusing on the following areas:

- Protecting and planting trees along riparian areas;

- Agricultural and forestry runoff management;
- Controlling streambank erosion;
- Planning timber harvests away from sensitive areas to prevent erosion and increased peak flows;
- Repairing and enhancing road/stream crossings to reduce erosion risk;
- Identifying road problems and prioritizing their repair;
- Replacing instream structural components to trap and store sediment.

Management agencies with responsibilities for implementing this TMDL include: Umpqua National Forest, U.S. Bureau of Land Management, Oregon Department of Agriculture and the Oregon Department of Forestry. These agencies have developed water quality management plans to address loadings identified in the 1988 TMDLs and/or are developing those plans now.

TMDL Report: This report presents the Little River TMDLs for public review. It addresses the elements of a TMDL required by the Environmental Protection Agency. These elements include:

- A description of the geographic area to which the TMDL applies;
- Specification of the applicable water quality standards;
- An assessment of the problem, including the extent of deviation of ambient conditions from water quality standards;
- The development of a loading capacity including those based on surrogate measures and including flow assumptions used in developing the TMDL;
- Identification of point sources and non-point sources; development of Waste Load Allocations for point sources and Load Allocations for non-point sources;
- Development of a margin of safety; and
- An evaluation of seasonal variation.

The appendices contain a more detailed description of the studies, computer modeling, references, and data analyses that were done to develop the TMDLs. A Water Quality Management Plan is also presented.

These documents and several public summary documents are available upon request at locations within the Little River watershed and can be found on the DEQ website: http://waterquality.deq.state.or.us/wq/.

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DRAFT LITTLE RIVER WATERSHED TMDL (TOTAL MAXIMUM DAILY LOAD)

1. INTRODUCTION

This TMDL for the Little River Watershed addresses elements required by the Environmental Protection Agency (EPA) for Total Maximum Daily Load (TMDL) development. These elements are also addressed in the accompanying Water Quality Management Plan (WQMP). The WQMP was prepared by local partners and the Oregon Department of Environmental Quality (DEQ). This TMDL will guide the reader to the elements contained in the WQMP and provide additional supporting information.

For this Little River TMDL, a significant portion of the information and analysis needed for establishing the TMDLs was provided by the Umpqua National Forest and the Roseburg District Bureau of Land Management (BLM). The Water Quality Restoration Plan (WQRP) submitted by these federal agencies (Appendix C) contains discussions of important aspects of this TMDL and WQMP, and in many cases the reader will be directed to the WQRP for additional information.

1.1 OREGON'S TOTAL MAXIMUM DAILY LOAD PROGRAM (GENERALLY DEFINED)

The quality of Oregon's streams, lakes, estuaries and groundwater is monitored by the DEQ and a variety of other partners. This information is used to determine whether water quality standards are being met and, consequently, whether the beneficial uses of the waters are being protected. Beneficial uses in the Little River Watershed include fisheries, aquatic life, drinking water, and recreation. Specific state and federal regulations are used to determine if violations of water quality standards have occurred; these regulations include the federal Clean Water Act of 1972 and its amendments; 40 Codified Federal Regulations 131; Oregon Administrative Rules (OAR Chapter 340); and Oregon Revised Statutes (ORS Chapter 468).

The term "water quality limited" is applied to streams and lakes where required treatment processes are being used, but violations of state water quality standards are still occurring. With a few exceptions, such as in cases where violations are due to natural causes, the state must establish a Total Maximum Daily Load or TMDL for any waterbody designated as water quality limited. A TMDL is the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards.

The total permissible pollutant load is allocated to point, nonpoint, background, and future sources of pollution. Wasteload Allocations are portions of the total load that are allotted to point sources of pollution, such as sewage treatment plants or industries. The Wasteload Allocations are then used to establish effluent limits in the facilities' discharge permits. Load Allocations are portions of the TMDL that are allocated to either natural background sources, such as soils, or to nonpoint sources, such as agriculture or forestry activities. Allocations can also be set aside in reserve for future uses, although there are no such allocations in this Little River TMDL. Simply stated, allocations are quantified pollution reduction measures that assure compliance with water quality standards. The TMDL is the total of all developed allocations.

The Clean Water Act requires that each TMDL be established with a margin of safety. This requirement is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and water quality. The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, wasteload allocations, and loading allocations. The margin of safety may also be explicitly stated as an added, separate allocation in the TMDL calculation. The margin of safety is not meant to compensate for a failure to consider known sources.

Implicit margins of safety were developed for temperature, pH, and sediment in this TMDL and will be discussed further.

Recently several agencies have taken proactive roles in developing management strategies in the Little River Watershed. Water quality management plans for forested and agricultural lands that address both nonpoint and point sources of pollution basin wide are currently under development. These management efforts will require stakeholders, land managers, public servants and the general public to become knowledgeable about water quality issues in the Little River Watershed.

1.2 ORGANIZATION OF THIS DOCUMENT

Regulations require that a Total Maximum Daily Load have certain essential components:

Geographic Description
Source Assessment
Loading Capacity
Loading Allocations
Margin of Safety
Seasonal Variation and Critical Conditions
Reasonable Assurance of Implementation
Public Involvement

This document contains TMDLs for temperature, pH, and sediment. Some of the TMDL components will be exactly the same for all three parameters. Therefore, the discussions of Geographic Description, Reasonable Assurance of Implementation, and Public Involvement will cover all three parameters. The Source Assessment, Loading Capacity, Loading Allocations, and Margin of Safety will be different for each parameter, so these components will be discussed individually. The section entitled “Temperature TMDL” includes these four components for temperature; likewise, the sections called “pH TMDL” and “Sediment TMDL” also contain these four components.

2. GEOGRAPHIC DESCRIPTION

This TMDL has been developed to address water quality concerns for the Little River and eight of its tributaries. The geographic scope of these TMDLs is the Little River Watershed, and the TMDLs apply to all perennial streams within the watershed. The Little River Watershed comprises an area managed in the higher portions by the United States Bureau of Land Management (BLM) and Forest Service (USFS), with holdings managed by private timber interests, and agricultural operations and rural residential areas in the lower parts of the system.

The Little River Watershed, part of the North Umpqua subbasin, is home to productive forested lands and contains streams with historically abundant salmonid populations. This TMDL and WQMP provide assessment information and goals from which to plan restoration and enhancement efforts.

The area covered by the TMDL and WQMP includes forest land managed by the USFS, BLM, and private timber companies, as well as some agricultural and rural residential lands managed by private landowners. The federal portion of the Little River Watershed is an Adaptive Management Area as defined by the Northwest Forest Plan (1994, USDA, USDI), with special emphasis on the development and testing of approaches to integration of intensive timber production with restoration and maintenance of high quality riparian habitat. Private forest lands are managed under the Oregon Forest Practices Act (FPA).

Of the 131,850 acres within the Little River Watershed, 63,590 (48%) are managed by the Umpqua National Forest, 19,274 (15%) by the BLM, and the remaining 48,986 (37%) acres by private timber companies (Seneca-Jones Timber is currently the largest private landowner) and agricultural and rural residential landowners. The Umpqua National Forest and the BLM worked closely together and with DEQ in the development of the WQRP.

The only permitted point source in the watershed with direct discharge to surface water is the wastewater treatment plant at the Umpqua National Forest's Wolf Creek facility. There are no suction dredge or stormwater general permits in the watershed.

For more complete descriptions of the Little River Watershed, please see the accompanying WQMP at pages 81-82, and the federal agencies' WQRP (Appendix C) at pages 4-13.

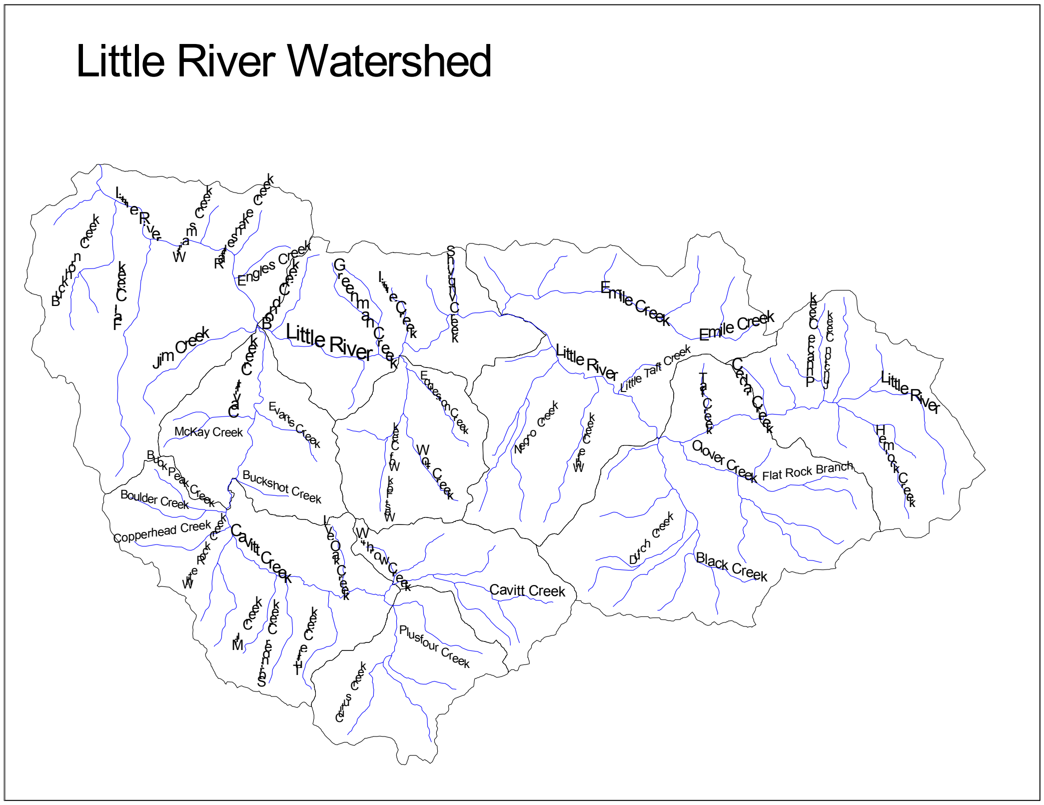

Figure 1. Little River Watershed

3. WATER QUALITY IMPAIRMENTS

As a result of water quality standard summer exceedances for temperature, nine stream segments are included on Oregon's 1998 Clean Water Act Section 303(d) list. Monitoring has shown that water quality in the Little River Watershed does not meet state water quality standards all of the time. Some tributary monitoring indicates that areas of the watershed do achieve WQ standards even during peak loading periods.

In addition to the temperature listings, two stream reaches are listed for sediment, four reaches are listed for pH, and two reaches are listed for habitat modification. Table 1 below lists the stream reaches on the § 303(d) list, together with the applicable criterion that is exceeded, and listed stream miles.

Table 1. Little River Watershed 303(d) Listed Segments, Applicable Water Quality Standards, and Stream Miles Listed

Waterbody	Parameter	Applicable Water Quality Standard	Stream Miles
Black Creek, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	5.2
Cavitt Creek, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	14.0
Cavitt Creek, mouth to Plusfour Creek	Sediment	*OAR 340-041-0285(2)(j)*	10.8
Cavitt Creek, mouth to Plusfour Creek	Habitat Modification	*OAR 340-041-0285(2)(i)*	10.8
Cavitt Creek, mouth to Evarts Creek	pH	*OAR 340-041-0285(2)(d)(A)*	2.5
Clover Creek, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	5.4
Eggleston Creek, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	2.7
Emile Creek, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	7.5
Emile Creek, mouth to RM 1.0	pH	*OAR 340-041-0285(2)(d)(A)*	1.0
Flat Rock Branch, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	2.9
Jim Creek, mouth to RM 2.0	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	2.0
Little River, mouth to Hemlock Creek	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	25.4
Little River, mouth to headwaters	Sediment	*OAR 340-041-0285(2)(j)*	30.2
Little River, mouth to headwaters	Habitat Modification	*OAR 340-041-0285(2)(I)*	30.2
Little River, mouth to White Creek	pH	*OAR 340-041-0285(2)(d)(A)*	17.8
Wolf Creek, mouth to major falls	pH	*OAR 340-041-0285(2)(d)(A)*	1.5
Wolf Creek, mouth to headwaters	Temperature - Rearing	*OAR 340-041-0285(2)(b)(A)*	1.5
Total stream miles listed		**Temperature - Rearing**	**66.6**
Total stream miles listed		**Habitat Modification**	**41.0**
Total stream miles listed		**Sediment**	**41.0**
Total stream miles listed		**pH**	**24.3**

4. TEMPERATURE TMDL

Table 2 below summarizes the components of the Temperature TMDL:

Table 2. Little River Watershed Temperature TMDL Components

State/Tribe: Oregon

Waterbody Name(s): All perennial streams within the 5th field HUC (hydrologic unit code) 1710030111– Little River Watershed, Mouth to Headwaters

Point Source TMDL: X Nonpoint Source TMDL: X (check one or both)

Date: April, 2001

Component	***Comments***
Pollutant Identification	*Pollutant:* Solar Flux (Heat Energy), expressed as BTUs per square foot of stream surface. *Anthropogenic Contribution:* Excessive solar energy input from changes in riparian vegetation and flow regimes.
Target Identification *CWA 303(d)(1)* *40 CFR 130.2(f)*	*Applicable Water Quality Standards* **Temperature: OAR 340-041-0285(2)(b)(A)** The seven-day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a Department-approved basin surface water temperature management plan: **64°F (17.8°C)** or- **55°F (12.8°C).** Where **55°F (12.8°C)** applies during times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and from the gravel. *Loading Capacity* • No more than 88 $BTU \cdot ft^{-2} \cdot day^{-1}$ solar loading as an average measured value over perennial stream length, or attainment of effective shade, resulting in system potential or climax solar radiation loading.
Existing Sources *CWA 303(d)(1)*	*Anthropogenic sources of thermal gain from riparian vegetation removal:* • Forest and road management within riparian areas; agricultural management; rural residential development *Anthropogenic sources of thermal gain from channel modifications:* • Timber harvest, roads, agricultural activities
Seasonal Variation *CWA 303(d)(1)*	*Stream Temperature period of interest*: June 1 through September 15. Solar energy inputs are at a maximum during this period, and stream flows are at a minimum.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Wasteload Allocations*: Wolf Creek Sewage Treatment Plant's effluent temperature is limited to 24.9 degrees C, which is warmer than any effluent the plant discharges. Wasteload allocation is 535,766 kilocalories per day. *Load Allocations:* 88 BTUs per square foot of water surface per day (146,529,885.6 kilocalories per day for modeled reach); effective shade levels between 90% and 98% based on stream width.
Margin of Safety *CWA 303(d)(1)*	*Implicit margin of safety:* Conservative assumptions in modeling; assumption of no tributary cooling.
WQS Attainment Analysis *CWA 303(d)(1)*	• Statistical demonstration of relationship between temperature and current shade conditions. • Analytical assessment of simulated temperature change related to allocated solar loading.
Public Participation (40 CFR 25)	***See page 63 of the WQMP in addition to information contained herein.***

4.1 GEOGRAPHIC COVERAGE OF TMDL

This Temperature TMDL will apply to all perennial streams within the Little River Watershed.

4.2 APPLICABLE WATER QUALITY STANDARDS

BENEFICIAL USES

The Oregon Environmental Quality Commission has adopted numeric and narrative water quality standards to protect designated beneficial uses. OAR 340–41–322, Table 3 lists the designated beneficial uses for Umpqua Basin waters. These uses, as well as the specific beneficial uses occurring in the Little River Watershed are presented in Table 3 below:

Table 3. Umpqua Basin Designated Beneficial Uses Occurring in the Little River Watershed

Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Industrial Water Supply	✓	Salmonid Fish Rearing	✓
Irrigation	✓	Resident Fish and Aquatic Life	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Navigation & Trans.		Hydro Power	

Numeric and narrative water quality standards are designed to protect the most sensitive beneficial uses. In the Little River Watershed, resident fish and aquatic life and the life stages of cold water fish are the most sensitive beneficial uses affected by stream temperature, pH, sedimentation and habitat modification.

STREAM TEMPERATURE

A seven-day moving average of daily maximums (7-day statistic) was adopted as the statistical measure for the stream temperature standard. Absolute numeric criteria are deemed action levels and can determine water quality standard compliance (**Table 4**). The numeric criteria adopted in Oregon's water temperature standard rely on the biological temperature limitations considering sensitive *indicator species*. An extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the *1992-1994 Water Quality Standards Review Final Issue Papers (DEQ, 1995)*.

Table 4. Applicable Water Temperature Standards	
Water Temperature Standard *OAR 340-041-0285(2)(b)(A)*	**7-Day Statistic**
Basic Absolute Criterion – Applies year long in all streams in the basin, with the exception of those that qualify for the *salmonid spawning, egg incubation and fry emergence criterion*.	≤64°F (17.8°C)
Salmonid Spawning, Egg Incubation and Fry Emergence Criterion – Applies to stream segments designated as supporting native salmonid spawning, egg incubation and fry emergence for the specific times of the year when these uses occur.	≤55°F (12.8°C)

No data was available for determining system compliance with temperature criteria designed to be applied at times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and from the gravel. DEQ is committed to determine the status of this system for this criterion through future monitoring efforts.

Implementation Program Applicable to All Basins (OAR 340-041-0120) states, in part:

(11)(a) It is the policy of the Environmental Quality Commission (EQC) to protect aquatic ecosystems from adverse surface water warming caused by anthropogenic activities. The intent of the EQC is to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming of surface waters, to encourage the restoration of critical aquatic habitat, to reverse surface water warming trends, to cool the waters of the state, and to control extremes in temperature fluctuations due to anthropogenic activities:

The first element of this policy is to encourage the proactive development and implementation of best management practices or other measures and available temperature control technologies for nonpoint and point source activities to prevent thermal pollution of surface waters.

. . . .

(11)(c) The temperature criteria in the basin standards establish numeric and narrative criteria to protect designated beneficial uses and to initiate actions to control anthropogenic sources that adversely increase or decrease stream temperatures. Natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions. These exceedances are not water quality standards violations when the natural conditions themselves cause water temperatures to exceed the numeric criteria. In these situations the natural surface water temperatures become the numeric criteria. In surface waters where both natural and anthropogenic factors cause exceedances of the numeric criteria, each anthropogenic source will be responsible for controlling, through implementation of a management plan, only that portion of temperature increase caused by the anthropogenic source.

OAR 340-041-0026 (3)(a)(D) addresses temperature management plans and sets forth the policy for situations where temperature criteria are not met:

Anthropogenic sources are required to develop and implement a surface water temperature management plan which describes the best management practices, measures, and/or control technologies which will be used to reverse the warming trend of the basin, watershed, or stream segment identified as water quality limited for temperature;

Sources shall continue to maintain and improve, if necessary, the surface water temperature management plan in order to maintain the cooling trend until the numeric criterion is achieved or until the Department, in consultation with the Designated Management Agencies (DMAs), has determined that all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted. In this latter situation, the temperature achieved after all feasible steps have been taken will be the temperature criterion for the surface waters covered by the applicable management plan. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance.

BACKGROUND

Stream temperature is an expression of heat energy per unit of volume, which in turn is an indication of the rate of heat exchange between a stream and its environment. The heat transfer processes that control stream temperature include solar radiation, longwave radiation, convection, evaporation and bed conduction (Wunderlich, 1972; Jobson and Keefer, 1979; Beschta and Weatherred, 1984; Sinokrot and Stefan, 1993; Boyd, 1996). With the exception of solar radiation, which only delivers heat energy, these processes are capable of both introducing and removing heat from a stream.

Excessive summer water temperatures in several tributaries and the Little River mainstem are likely reducing the quality of rearing habitat for spring and fall chinook, coho, winter and summer steelhead, cutthroat trout and pacific lamprey, all native anadromous species.

Aquatic life is sensitive to water temperature. Salmonid fish, often referred to as cold water fish, and some amphibians appear to be highly sensitive to temperature. In particular, coho salmon and spring chinook are among the most temperature sensitive of the cold water fish species within this basin. Oregon’s water temperature standard employs logic that relies on using these indicator species, which are the most sensitive. If temperatures are protective of these indicator species, other species will share in this level of protection. Coho salmon are listed as a Threatened Species pursuant to the Endangered Species Act within the Little River Watershed, which is part of the Oregon Coast evolutionarily significant unit. Steelhead trout is a candidate for listing in the same Oregon Coast evolutionarily significant unit.

Thermally induced stresses can result in fish mortality. This can be attributed to interactive effects of decreased or lack of metabolic energy for feeding, growth or reproductive behavior, increased exposure to pathogens (viruses, bacteria and fungus), decreased food supply (impaired macroinvertebrate populations) and increased competition from warm water tolerant species. This mode of thermally induced stress and/or mortality, termed indirect or sublethal, is more delayed, and occurs weeks to months after the onset of elevated temperatures.

4.3 FACTORS AFFECTING STREAM TEMPERATURES

Many factors affect stream temperatures. Some of them are beyond human control, such as latitude, aspect, climate and weather. Other factors, where humans can and have influenced stream temperatures, include heated discharges, removal or planting of vegetation intercepting solar radiation, the width and depth of the channel, the level of flow, and channel complexity.

Solar radiation. While we cannot control the radiation reaching earth from the sun, we can often control over how much of that radiation actually reaches the surface of a stream. Shade from two primary sources intercepts solar radiation before it reaches the stream. First is topographic shade, i.e., the shade produced on the stream by the terrain. While there can be changes in topography caused by human activity, for purposes of this TMDL it is assumed that topographic shade will not change.

Vegetation is the other source of shading of a stream. Riparian vegetationis the most significant factor affecting stream temperature over which we have control. Past management practices have removed significant portions of the riparian vegetation that existed previously. Restoring that vegetation is the activity most likely to reduce stream temperatures.

Channel form. A stream that is wide and shallow will be subject to greater heating than one that is narrow and deep due largely to the greater surface area exposed to solar radiation. Many streams have become wider due to increased peak flows following extensive logging activity, including riparian harvests. Removal of streamside vegetation can also reduce bank stability, leading to increased channel width.

Flows. As flows decrease, there is less water in the stream subject to the same solar radiation, which will generally cause increased heating. However, research in the Umpqua basin has revealed areas where stream temperature decreases as flows get very low (Smith, 2000). This phenomenon is related to the percentage of groundwater in the stream. As groundwater, which is very cool, becomes a larger percentage of the flow when surface flows decrease, the stream temperature becomes cooler. But even in those streams, temperature increases as flows decrease until flows get very low.

Channel complexity/large wood. In some streams, high peak flows have scoured stream bottoms down to bedrock. In others, all the large wood was removed several decades ago when that was thought necessary for fish passage. The result is that many channels lack the complexity necessary to provide quality salmonid habitat. A complex channel contains different components like pools and riffles, and contains large wood that slows the velocity of the water and allows sediments to drop out, building substrate on the bedrock. As gravels build up, water flows through them and is not exposed to solar radiation. In this way, these more complex channels are expected to have reduced stream temperatures.

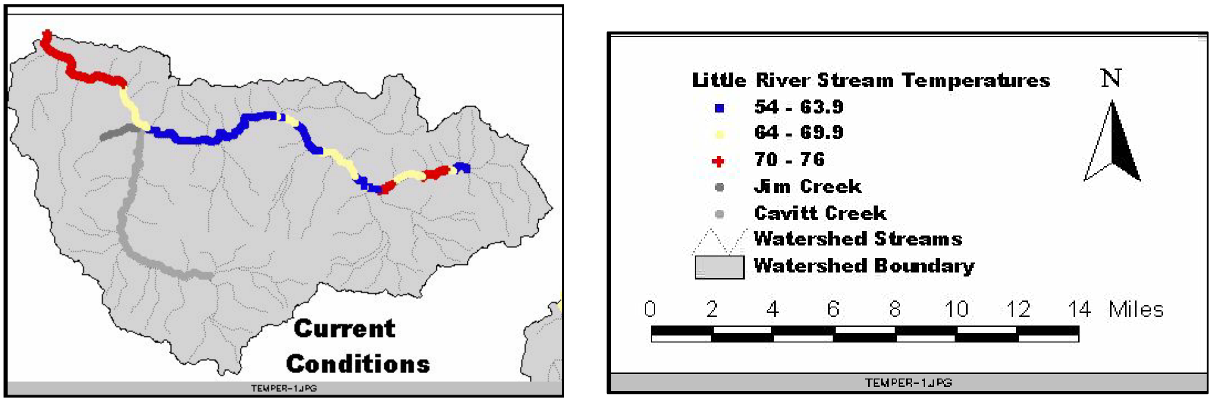

Figure 2. Distribution of 1995 Maximum Stream Temperatures in Reaches Used for Modeling in Little River Watershed

4.3 CURRENT CONDITIONS

Figure 2 above shows the maximum temperatures in the modeled reaches of the Little River Watershed as measured in 1995. As the chart shows, large areas of the mainstem Little River were below the stream temperature-rearing criterion of 64 degrees F. However, significant portions of the mainstem, including the entire area downstream of Cavitt Creek, exceed 64 degrees F., with some going as high as 76 degrees F.

The federal agencies conducted temperature monitoring in Little River and its tributaries. The temperature data for these reaches is summarized in **Figure 3** below (This figure is Table 15 of Appendix C, the Water Quality Restoration Plan for Little River prepared by the Forest Service and BLM.) The river mile axis shows where the various tributaries enter the mainstem. The table shows that several tributaries and stretches of Little River do not exceed the temperature criterion. However, many of the tributaries did show significant warming in excess of the water quality standard.

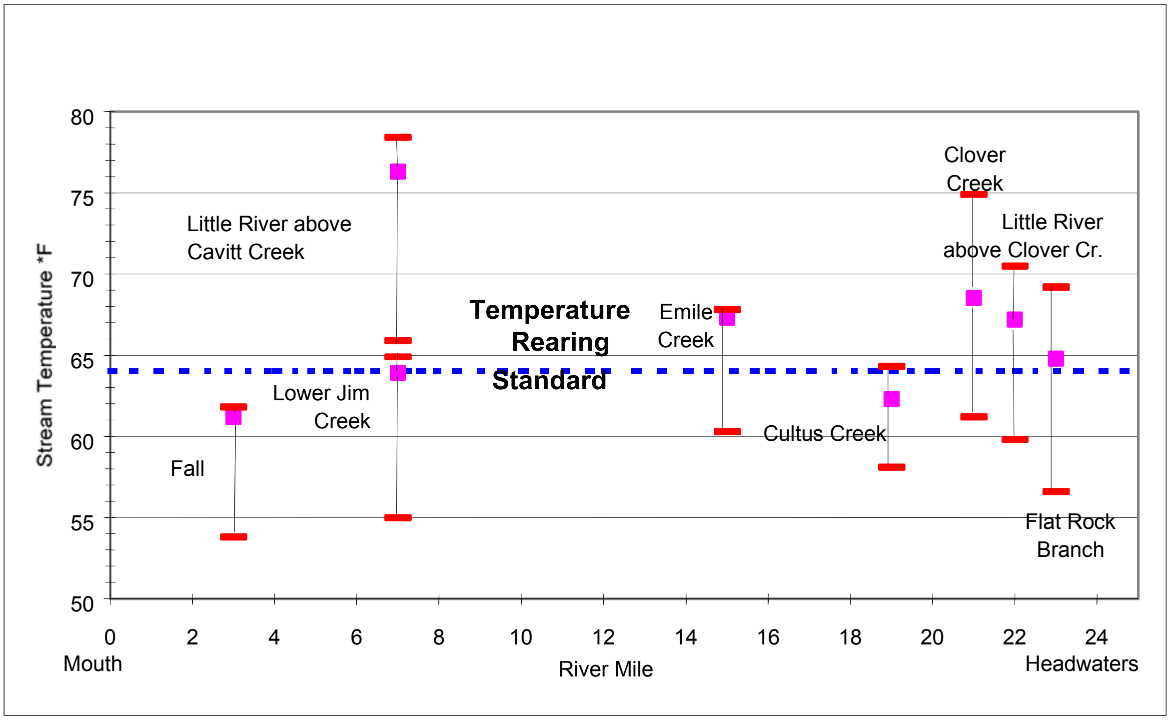

Figure 3. Recent temperatures in the Little River Watershed
Note: The small squares represent the mean temperature value for each site, while the small top and bottom bars show the range of temperature values for each site.

Riparian area and channel morphology disturbances have resulted from past timber management and agricultural activities. Although timber harvest and agriculture continue in the Little River Watershed, altered management practices can minimize pollutant delivery. These practices should be designed to implement the TMDL load allocations presented in this document.

4.5 FLOWS

WATER SUPPLY AND WATER RIGHTS

Figure 4 below shows natural streamflows, water rights, and water consumption in the Little River Watershed. Water is withdrawn from Little River and tributaries, as well as nearby groundwater sources, primarily for domestic and irrigation uses. A total of 111 domestic water rights and 109 irrigation rights have been issued by the State of Oregon Water Resources Department (OWRD). Summer base flows in the lower reaches of Little River and Cavitt Creek are reduced by water withdrawals. The volume that is appropriated, however, is relatively small, as the Oregon Water Resources Department estimates that only 50% of consumptive rights are being utilized at any given time. See **Table 5** for a summary of water rights issued by the state.

Table 5. **Water Rights Issued**							
Consumptive Uses Cubic Feet/Second							
Irrigation	Agriculture	Domestic	Industrial	Municipal	Recreational	Miscellaneous	Total
9.86	0.05	1.24	0.36	0.00	0.11	0.28	11.90

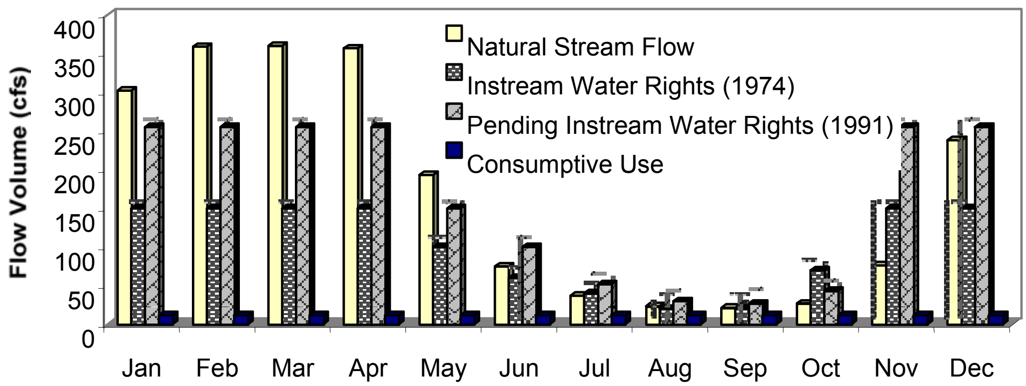

Figure 4. Natural stream flow at 80% exceedance level, instream water rights (1974), pending instream water rights (1991), and consumptive use occurring over one year at the mouth of Little River.

Appropriation of water is based on both water right seniority and water availability. As streamflows recede, those users with junior rights are the first required to curtail their water use. Senior water right holders are allowed to continue using water, even in dry years and low flow conditions, as long as water is available to meet the demand under their priority date. Pending and issued instream water rights on Little River are based on flow requirements necessary to maintain fish habitat as determined by ODFW. The priority dates for the instream rights on Little River are 1974 and 1991. Because these rights are very junior, the amount of consumptive use subject to regulation is very small. Even if all users were regulated off, it is unlikely the instream rights would be met during the dry summer months due to low seasonal streamflows.

New water rights for irrigation from Little River and tributaries are no longer being issued since natural streamflows are not sufficient to meet existing consumptive and instream rights during the irrigation season. Domestic rights may still be obtained if the applicant can demonstrate that surface water is the only available source for their use. The Oregon Department of Fish and

Wildlife (ODFW) and OWRD have identified the Little River Watershed as high priority for streamflow restoration efforts under the Oregon Plan for Salmon and Watersheds. The OWRD will be employing a number of measures designed to enhance summer flows for the benefit of anadromous species. (OWRD, personal communication with Dave Williams, Watermaster, Douglas County.) These potential streamflow enhancements were not quantified for purposes of this TMDL; instead, they serve as a margin of safety.

4.6 RIPARIAN SHADE

This TMDL focuses on riparian shade as the primary strategy for meeting water quality standards for temperature. There are a variety of reasons for this focus: Quantitative methods have been developed to measure shade, and, although imperfect, provide a way to project future shade conditions and their impact on stream temperature. The condition of riparian vegetation is one that humans can control.

Further, improvements in riparian vegetation will also address, directly or indirectly, other factors which affect stream temperature. Healthy riparian zones are expected to stabilize streambanks and reverse the widening trend seen in many streams. Riparian restoration is also expected to result in an increase in summer streamflows, as the riparian areas begin to provide water storage and connection to the stream's floodplain.

In the long run, riparian vegetation is even expected to improve channel complexity as the vegetation matures and then falls into the stream. Increasing a stream's complexity will enhance salmonid habitat. (In the short term, instream placement of habitat structures may be needed in places to provide quality habitat.)

In addition, riparian shade will be beneficial for other aspects of water quality. The following section will describe the relationship between pH and temperature, and increased riparian shade will lead to improvement in the pH conditions. Streambank stability will reduce sediment inputs. A healthy riparian zone will filter sediments from activities in the uplands. Finally, riparian vegetation provides a buffer that can protect the stream from toxic discharges, and may be effective in taking up and neutralizing some toxic compounds.

In addition to the water quality benefits, a healthy riparian zone will provide additional environmental benefits including habitat for wildlife and a transportation corridor for their movement.

4.7 LOADING CAPACITY

In order to determine the Loading Capacity of Little River for heat energy, intensive field measurements were taken of temperature patterns as well as measurements of channel and vegetation height, width and density, and streamflow.

These data were used as inputs into the mathematical model Heat Source which simulates stream heating. See Appendix A for a full explanation of the model and its inputs. The field data were used initially to calibrate the model for Little River. Once the model was calibrated, it could be used to project stream temperatures under various vegetation conditions.

Two future scenarios were modeled to see their effect on temperature. The first scenario assumed that there were trees of an average height of 140 feet within all possible buffers currently required by law. This scenario was termed the "Current Management Potential" or

CMP. The second scenario assumed that there were trees of an average height of 140 feet within a riparian buffer large enough so that maximum shade was produced except where existing roads are located. This scenario was termed the “System Potential” or SP.

Under either scenario, the model shows that the maximum temperature criterion of 64 degrees will NOT be met everywhere in Little River. It is predicted that under the CMP scenario, nearly half the reaches in the river would exceed the 64-degree criterion.

The Heat Source model was also used to estimate the current load of heat energy during the critical summer period. Based on existing vegetation, the model shows that an average of 366 BTUs reach each square foot of stream surface per day. In contrast, at system potential vegetation, only 88 BTUs will reach each square foot of stream surface. Although this will not ensure 64 degrees everywhere in the river, it is the best possible riparian vegetation that can be expected. Natural disturbances (e.g., fire) may further increase solar inputs over time, but it is inappropriate to estimate these, or try to manage for a “natural level of disturbance.”

Since the 64-degree F. criterion will not be met everywhere no matter how much shade is grown, there is no additional heating capacity that can be allocated. Thus, the heat energy Total Maximum Daily Load is an average of 88 BTUs per square foot of stream surface per day. That limit can be achieved by growing vegetation averaging 140 feet in height along the riparian zone, wherever the vegetation will grow (system potential vegetation). For Little River, system potential vegetation consists of a conifer-dominant riparian stand with mixed hardwoods

4.8 LOADING ALLOCATION

The Loading Allocation for all nonpoint sources is the same: an average of 88 BTUs per square foot of stream surface per day, as discussed in the previous section. In order to determine a watershed-wide daily load, the rate of 88 BTUs per square foot was multiplied by the number of square feet of stream surface in the modeled reaches: Little River, Cavitt and Jim Creeks. While this does not represent all streams within the watershed, it does quantify the heat energy loading allocation as a daily load. Expressed in metric terms, the Loading Allocation for background sources is 146,529,885.6 kilocalories per day.

4.9 SHADE TARGETS

Total Maximum Daily Loads must be quantified. While the TMDL can be calculated in terms of heat energy (BTUs) per square foot, as was done above, this limit is not meaningful to most land managers and owners. A more meaningful target is shade quantity, because of the relationship between shade and stream temperature. In this way, shade is being used as a surrogate for stream temperature. Therefore, the following analysis was done using the expected future conditions based on the “System Potential” simulation.

In the modeled section of Little River, current Effective Shade is approximately 74.5 %, as estimated by the Heat Source model. When vegetation reaches system potential, Effective Shade is predicted to be 93.7%. In terms of shade, then, the TMDL surrogate target for Little River is 93.7% Effective Shade.

The next step examines the relationship of expected Effective Shading values at system potential vs. summer low flow stream wetted width, as shown in Figure 5. Each point in the graph represents one of the 100-meter stream reaches modeled with Heat Source. For each segment, the summer low flow wetted width of the stream is compared with the modeled system potential Effective Shade. As **Figure 5** shows, narrower streams are likely to achieve more Effective Shade than wider streams. However, wider streams may have a high percentage of Effective Shade, particularly if some of the shade comes from the terrain.

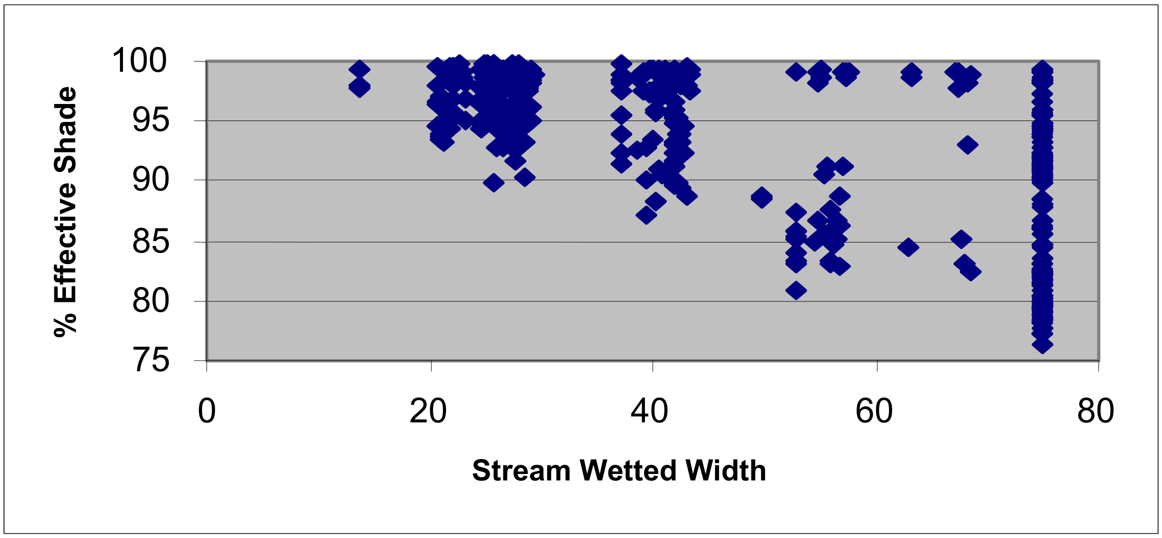

Figure 5. Modeled Effective Shade for Various Stream Widths at System Potential Vegetation

The next step "lumps" the expected Effective Shades into groups. Effective Shade values were grouped by their corresponding wetted widths: 0-19.9 feet, 20-39.9 feet, 40-59.9 feet and 60-75 feet (75 feet was the maximum wetted width in the system). Once grouped, the percentiles for each wetted width group were calculated. The percentile distribution of the wetted width groups is shown in **Figure 6**.

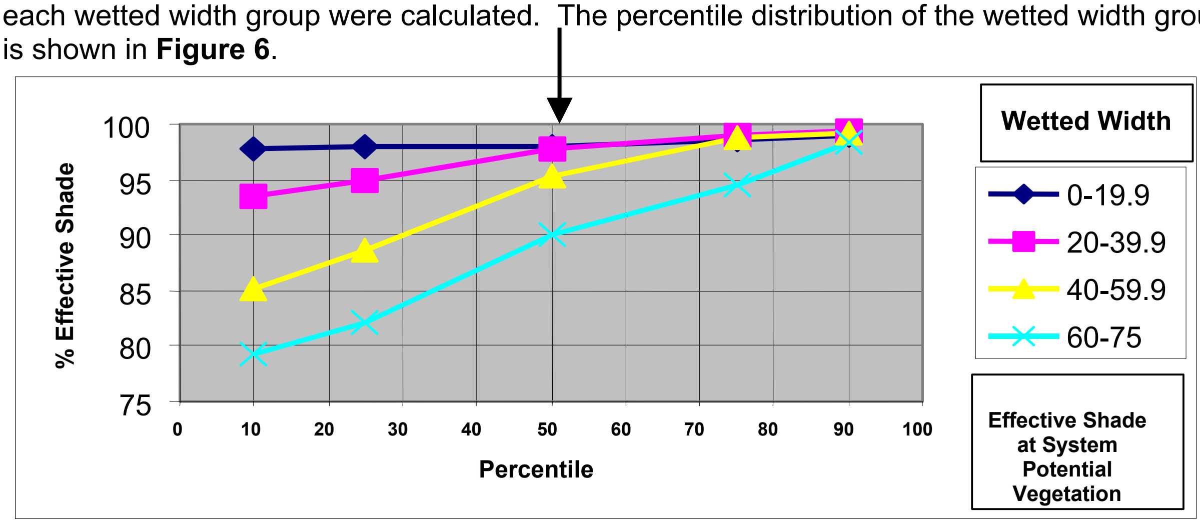

Figure 6. Effective Shade at System Potential Vegetation, by Stream Wetted Width.

The TMDL shade allocations were then taken from the 50th percentile values as shown in **Figure 6**.

With system potential vegetation, streams with wetted widths of less than 40 feet are expected to produce a median Effective Shade of 98%.

With system potential vegetation, streams with wetted widths between 40 and 60 feet are expected to produce a median Effective Shade of 95%.

With system potential vegetation, streams with wetted widths greater than 60 feet are expected to produce a median Effective Shade of 90%.

Providing a median shade value still allows a wide range of Effective Shades depending on specific conditions at the point of measurement. **Figure 7** shows current and expected Effective Shades in the Little River modeled reach. At system potential, the allocated Effective Shade values range from 100% to below 80%.

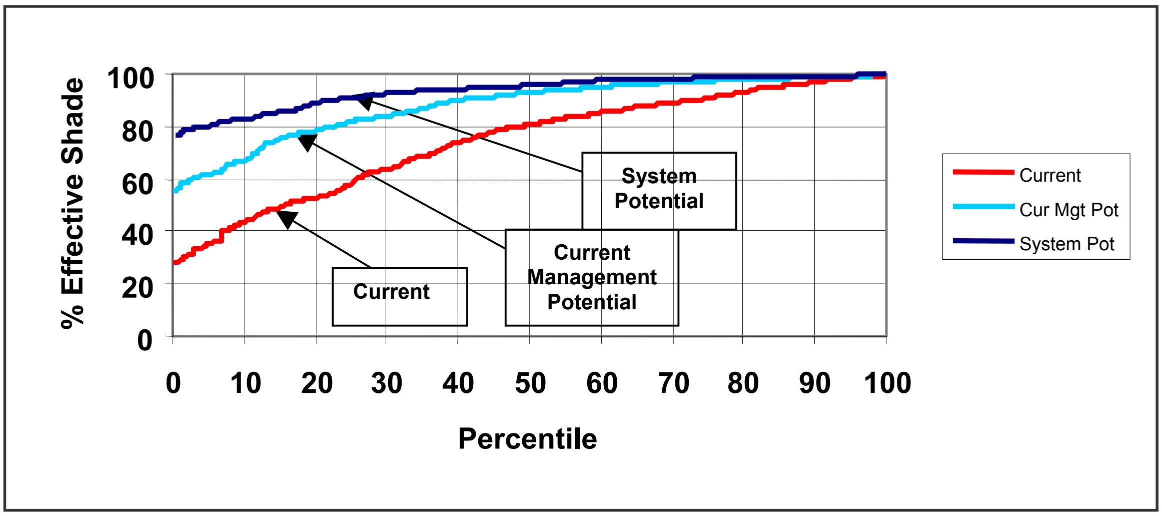

Figure 7. Distribution of Effective Shade Values Under Different Scenarios

STREAMS OUTSIDE MODELED REACH

In the upper portions of the watershed above the modeled reach, the Forest Service and BLM conducted an assessment using the Shadow model. This model looks at shade in a slightly different manner than Heat Source in that it looks at shade over the entire bankfull width of the stream, whereas Heat Source considers only vegetation that shades the wetted portion of the stream. This difference results in Heat Source predictions of Effective Shade that are often greater than what would be predicted using Shadow (although, depending on aspect and topographic shade, Heat Source shade predictions can sometimes be lower than Shadow predictions).

Heat Source is a data-intensive model, and data was not available to run the model on all streams in the watershed. However, using the Shadow model, the federal agencies were able to determine current shade levels for all streams in the watershed, as well as the shade that would be present with system potential vegetation. Their results are in **Table 6** below, which is also Table 16 of the Water Quality Restoration Plan Appendix C.

Although the two methods produce slightly different results, the methods are close enough that for purposes of shade targets, the shade values predicted by Heat Source and by Shadow will be assumed to be interchangeable. The reduced rate of warming anticipated from improving the shade on the streams outside the modeled reach, which was not taken into account in the model, provides a margin of safety, as discussed below.

Table 6. Current Shade Conditions and Potential Recovery for Little River and its Tributaries

Location	Existing Shade (%)	Target Shade (%) (System Potential)	Shade Loss (%)	Years to Full Site Potential Recovery
Hemlock Creek	87	91	- 4	45
Upper Little River	87	91	- 4	35
Pinnacle Creek	80	89	- 9	75
Junction Creek	83	89	- 6	30
Little River Canyon	78	83	- 5	60
Emile Creek	80	86	- 6	60
Upper Emile Creek	76	90	- 14	45
White Creek	84	90	- 6	45
Clover	87	88	- 1	15
Clover (Trib A)	85	91	- 6	35
Clover (Trib B)	86	91	- 5	35
Flat Rock Branch	90	91	- 1	10
Black Creek	80	90	- 10	50
Dutch	78	87	- 9	35
Upper Cavitt Creek	85	91	- 6	50
Cavitt Creek	67	84	- 17	85
Cultus Creek	84	91	- 7	50
Plus Four Creek	84	91	- 7	40
Tuttle Creek	80	91	-11	70
Buckhorn Creek	64	88	-24	52
Fall Creek	63	90	-27	47
Rattlesnake	88	90	- 2	25
Engles	80	90	-10	30
Jim Creek	67[1]	85	-18	46
Bond	88	88	0	0
Greenman	71	88	-17	45
Wolf-Egglestron	77	89	-12	38

1. A large fire in 1987 affected the target shade calculations in Jim Creek.

For streams other than the modeled portions of Little River, Cavitt Creek and Jim Creek, the target shade identified by the federal agencies for each stream will become the initial target for that entire stream. Over time, as methods and technologies improve, this target can be refined for the lower portions of the streams, potentially reducing the shading needed in this part of the system.

4.10 BUFFER WIDTH

Figure 8 shows the relationship between buffer width and stream temperature for Little River, as calculated with the Heat Source model. This shows Effective Shade increasing (stream temperature decreasing) as buffer width increases, but the increases become smaller as the buffer width gets larger. A buffer 200 feet wide appears to capture nearly all of the potential effective shade; any further increase in width does not contribute significantly to stream temperature control.

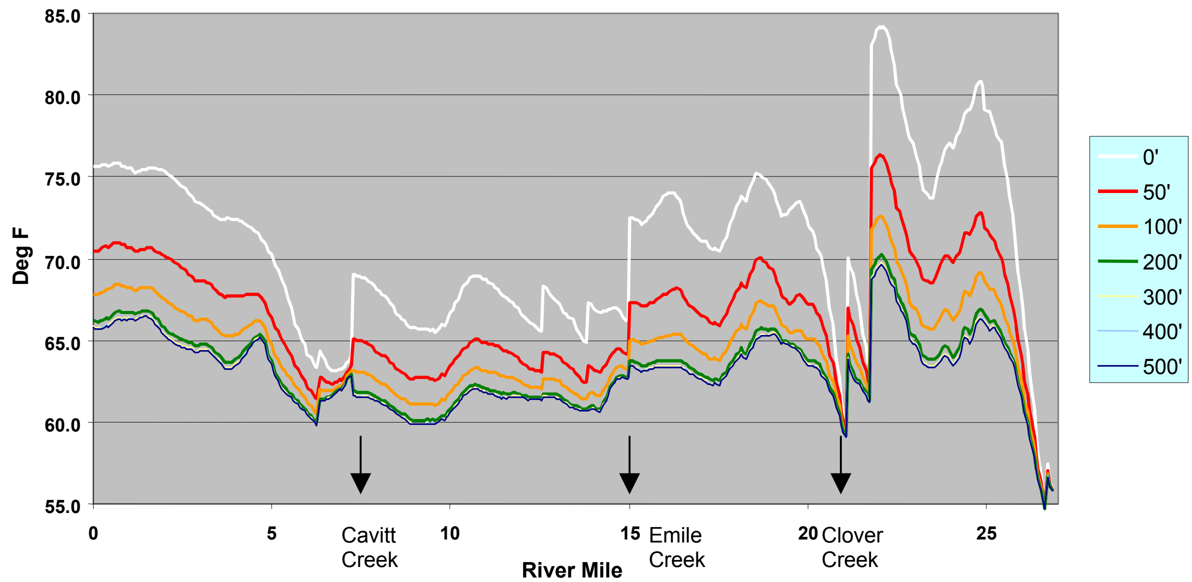

Figure 8. Temperature Effect of Various Buffer Widths

For further discussion of Figure 8, please see Appendix A.

For purposes of this TMDL, no minimum buffer width is specified. However, it will be the responsibility of the various designated management agencies to reach the Effective Shade target. It may be possible, for example, for the agricultural community to develop methods of achieving denser shade in a narrower buffer so that the shade target is met even though the buffer may be less than 200 feet. DEQ encourages native vegetation, which is likely to produce habitat and water quality conditions most similar to that in which aquatic species evolved.

The Oregon Department of Forestry (ODF) is responsible for ensuring that these TMDL targets will be met on private forest lands in the watershed. The Oregon Forest Practices Rules currently require a small no-touch buffer combined with a basal area retention requirement that was devised to protect water quality, including stream temperatures. These requirements are currently being studied to determine if they will achieve their objective. Please see the accompanying Water Quality Management Plan at pages 106-107 for more discussion of implementation of the TMDLs on private forest land.

The Oregon Department of Agriculture (ODA) is responsible for ensuring that these TMDL targets will be met on agricultural lands in the watershed. The Umpqua Agricultural Water Quality Management Area Plan (See Appendix D) contains provisions regarding riparian areas that are designed to protect water quality. This plan, adopted recently by ODA and the Board of Agriculture, will be reviewed at 2-year intervals, and can be adjusted if it appears that the requirements are not sufficient to meet the temperature Load Allocation. Please see the accompanying Water Quality Management Plan at pages 107-108 for more discussion of implementation of the TMDLs on agricultural land.

4.11 WATER QUALITY ATTAINMENT - TEMPERATURE CHANGE RELATED TO SOLAR LOADING CAPACITY

Predictive temperature modeling was conducted using Heat Source (Boyd, 1996). This model examines both the total energy transfer rates to the stream (i.e., the sum of heat energy transfer processes) and the response of water temperature to heat energy absorbed. Heat transfer processes considered in the analysis include solar radiation, longwave (thermal) radiation, convection, evaporation, and streambed conduction. This analysis has been developed using typical streamflows and channel characteristics commonly found in the Little River Watershed as well as conservative assumptions described in the margin of safety discussion.

Appendix A displays simulated stream temperature results. The modeling day selected (September 15) depicts seasonal worst case conditions. Anthropogenic sources provide no measurable increase in stream temperature when solar radiation loads are equal to or less than the loading capacity (Targeted Solar Loading = 88 BTU·ft-2·day-1). As demonstrated by simulation results in the Grande Ronde TMDL, stream flow is a key factor in stream heating. Lower flows typically correspond to increased stream heating. Although streamflow was held constant at low flow for the Little River TMDL model simulations, any streamflow enhancements that are achieved will further reduce the rate of warming. This provides an additional margin of safety in the TMDL.

Solar radiation loading of 88 BTU·ft^{-2}·day represents a reasonable starting point for defining loading capacity (i.e., the greatest amount of loading that surface waters can receive without violating water quality standards). Average flat plane solar radiation loads above the riparian canopy in mid-September are on the order of 366 BTU·ft^{-2}·day-1.

Figure 9 below shows that with system potential vegetation in the modeled reaches, about 50 % of the stream segments will be at or below the 64 degree F. temperature criterion.

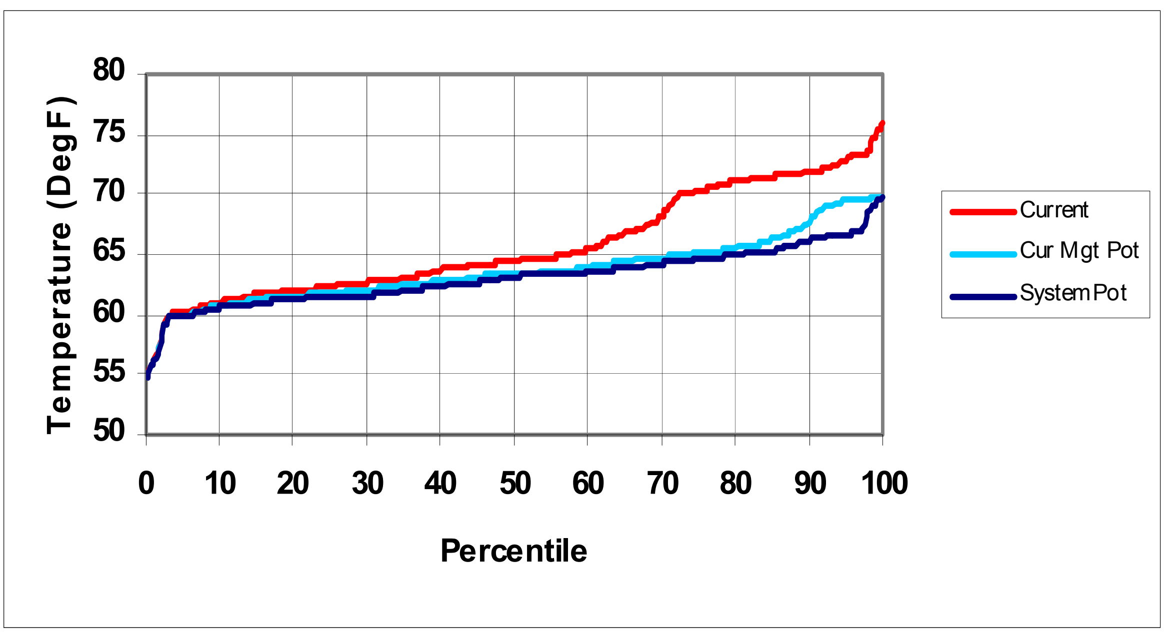

Figure 9. Percentile distribution of modeled reaches based on maximum temperature.

4.12 WASTELOAD ALLOCATIONS

The Umpqua National Forest operates a sewage treatment plant at its Wolf Creek Conservation Center in the Little River Watershed. As currently conducted, this activity is not affecting riparian and/or channel conditions. This activity is currently managed under the 10064 NPDES Permit. The 7Q10 dilution of stream water to effluent is 380:1, so even though the effluent is discharged at 22 degrees C, this will cause no more than 0.01 degree C. increase in stream temperature if the stream temperature is at the criterion (17.8 degrees C.). (7Q10 is a statistical measure of the streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval, or 1 in 10 chance of occurring in any given year. Daily stream-flows in the 7Q10 range are general indicators of prevalent drought conditions which normally cover large areas.) The potential stream temperature increase during a worst case scenario is not even measurable with current monitoring technology, and does not cause a "Measurable Temperature Increase" as defined in OAR 340-041-0006 (55) ("increase in stream temperature of more than 0.25 degrees F.").

EPA has indicated that a wasteload allocation is required for any discharge, regardless of quantity, to a water-quality limited stream. A way to assess the impact of the effluent on stream temperature is to use a DEQ formula to determine the wasteload allocations for temperature from a point source.

A review of the plant's Discharge Monitoring Reports shows that during the summer, the typical effluent temperature from the Wolf Creek plant is between 20° and 22° C., and has never exceeded 24° C. The 7Q10 flow for the period of interest is 13 cubic feet per second (cfs).

Temperature modeling has determined that the system potential temperature at the location of the treatment plant is 18° C.

To determine the temperature loading capacity (i.e., the highest allowable effluent temperature), the following equation was used:

$$T_{LC} = \frac{\left[\left(Q_E + 1/4\,Q_R\right) \bullet \left(T_P + \Delta T\right)\right] - \left(1/4\,Q_R \bullet T_P\right)}{Q_E}$$

WHERE,
TLC = Loading Capacity (Allowable Effluent Temperature)
TP = System Potential Temperature
TC = Numeric Criterion
ΔT = Allowable Temperature Increase at Edge of Mixing Zone (0.13 C.)
QE = Facility Design Flow
QR = 7Q10 (Low Flow)

Using this equation with the terms listed below, the Loading Capacity, or maximum allowable effluent temperature, is 24.9° C. Since the facility has never discharged effluent with a temperature higher than 24° C., no reduction in effluent temperature is required.

Facility Name	Receiving Water	7Q10 Low Flow (Q_R)	¼ River 7Q10 Low Flow (¼ Q_R)	Facility Design Flow (Q_E)	Maximum Critical Condition Effluent Temp.	System Potential Temp. (T_P)	Allowable Temp. Increase (ΔT)	Loading Capacity (Allowable Effluent Temp.) (T_{LC})	Wasteload Allocation Reduction in Effluent Temp.
Wolf Creek Conservation Center	Little River RM 12.75	13 cfs	3.25 cfs	.062 cfs	24° C.	18° C.	0.13° C.	24.9° C.	No reduction

Table 7 below summarizes the temperature loading allocations for Little River Watershed

Table 7. Temperature Allocation Summary

Nonpoint Sources

Source	Loading Allocation Distribution of Solar Radiation Loading Capacity
Natural	146,529,885.6 kilocalories per day.
Agriculture	0%
Forestry	0%
Urban	0%
Future Sources	0%

Point Source

Facility Name	*Receiving Water*	*Max. Critical Condition Effluent Temperature*	*Loading Capacity Allowable Effluent Temperature*	*Wasteload Allocation Reduction in Effluent Temperature*
Wolf Creek	Little River RM	24 C	24.9 C 535,766 kilocalories per day	No reduction

4.13 Implicit Margin of Safety – Stream Temperature

The following comprise the margin of safety implicit in the determination of the stream temperature TMDL:

- In predicting future stream temperatures in Little River, tributary temperatures other than for Cavitt Creek and Jim Creek were not changed based upon improved future riparian conditions but held to current temperature regimes for predictive model runs. The modeling work for this basin focused upon the mainstem. Temperature and flow sets from only the mouths of these tributaries prohibited predictive temperature modeling in the rest of the tributaries. Modeling of increased shade along Cavitt and Jim Creeks showed this increased shade to be highly effective at cooling stream temperatures in Little River. **The most significant cooling expected in the future will likely be for tributaries within this system.**

- Flow volumes used in calibrating the model were unchanged for future condition simulations. Any future flow enhancements will provide an additional margin of safety.

Groundwater inflow was assumed to be zero at all points in the system except for the reach on Little River between Emile and Wolf Creeks, where significant groundwater inflow was documented. Additional groundwater inputs and their cooling influence on stream temperatures via mass transfer/mixing were not accounted for.

- Heat Source modeling inputs restricted maximum future shade densities to 76%, except where existing shade is already denser. Density within any given stand can vary dramatically through seral stages. This shade evaluation process likely results in an underestimation of existing and future shade values.
- The shade overhang profile used in the calibration condition was unchanged in both of the future condition simulations. Expected increases in shade overhang that were not used in the simulation provide an additional margin of safety in the analysis.
- System potential mature vegetation is assumed to be late seral Douglas fir and mixed hardwood stands. In the Little River Watershed, undisturbed riparian areas generally progress towards late seral woody vegetation communities (mixed hardwood, but conifer dominated). System potential tree height during modeling was held to 140' based upon the mixed community of conifer (180') and hardwood (120') expected in the future.
- Roads which are currently inside the riparian corridor were assumed to remain in both of the future condition simulations. Future changes to the road network, such as road decommissioning or relocation of roads outside the riparian area, may allow additional riparian vegetation to grow, and thus serve as an additional margin of safety.
- Riparian restoration will likely, over time, result in a trend toward deeper, narrower streams, further reducing stream heating. This was not accounted for in the modeling, and therefore serves as an additional margin of safety.
- Reductions in human-induced sediment, leading to likely improvements in channel morphology, such as stream narrowing, could also reduce stream temperatures. These possible stream temperature reductions are not accounted for in the analysis and would be additional to those detailed in the separate analyses on sediment and temperature.
- Improved riparian areas may increase summertime flow by increasing the volume of water stored in riparian areas and slowly released during low flow conditions. Water stored as groundwater is cooler because it is not heated by solar radiation.
- Modeling was conducted using worst case scenarios of low flows and seasonal maximum high air and water temperatures.

4.14 SEASONAL VARIATION AND CRITICAL CONDITIONS

Section 303(d)(1) requires this TMDL to be "established at a level necessary to implement the applicable water quality standard with seasonal variations." Both stream temperature and flow vary seasonally from year to year. Water temperatures are coolest in winter and early spring months. Winter water temperature levels decrease dramatically from summer values, as river flows increase and available solar energy is at an annual minimum. Stream temperatures exceed state water quality standards in summer and early fall salmonid rearing months (June, July, August and September). Warmest stream temperatures correspond to prolonged solar radiation exposure, warm air temperature, low flow conditions and decreased groundwater contribution. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures. The analysis presented in this TMDL is performed for low flow periods in which controlling factors for stream temperature are most critical. This modeling effort hence reflects extreme temperature regimes in this system and clearly depicts critical temperature conditions. Future worst case temperatures will certainly run lower than those predicted in Appendix A.

This TMDL addresses only the 64 degree F. temperature criterion protecting salmonid fish rearing and migration, because not enough data was available to assess compliance with the spawning criterion of 55 degrees F., and because the streams' 303(d) listings are based on the rearing criterion. Future monitoring during spawning time periods will allow an assessment of whether the spawning criterion is being met.

5. pH TMDL

Table 8 below summarizes the pH TMDL components:

Table 8. Little River Watershed pH TMDL Components

State/Tribe: Oregon

Waterbody Name(s): All perennial streams within the 5th field HUC (hydrologic unit code) 1710030111– Little River Watershed, Mouth to headwaters.

Point Source TMDL:_____ Nonpoint Source TMDL: X (check one or both)

Date: February, 2001

Component	*Comments*
Pollutant Identification	pH is a measure of the concentration of hydrogen ions in a fluid, measured in Standard Units (S.U.) *Pollutants:* Heat energy *Anthropogenic Contribution:* Excessive Solar Energy Input; Excessive Nutrient Loading; Excessive Sedimentation
Target Identification *CWA 303(d)(1)* *40 CFR 130.2(f)*	*Applicable Water Quality Standards* **pH: OAR 340-041-0285 (2)(d)(A)** Fresh waters (except Cascade Lakes) and estuarine waters: pH values shall not fall outside the range of 6.5 to 8.5. *Loading Capacities:* System potential vegetation in riparian areas. As stream temperature decreases, pH is anticipated to decrease as well.
Existing Sources *CWA 303(d)(1)*	*Anthropogenic sources of thermal gain from riparian vegetation removal:* • Forest and road management within riparian areas; agriculture *Anthropogenic sources of thermal gain from channel modifications:* • Timber harvest, roads, agriculture *Anthropogenic sources of sediment:* • Timber harvest, roads, agriculture *Anthropogenic sources of nutrients:* • Timber harvest, agriculture, onsite sewage disposal systems, forest fertilization
Seasonal Variation *CWA 303(d)(1)*	*Time Period of Interest:* June through September pH is stream temperature-dependent in Little River; solar loading is at a maximum in summer, and stream flows are at a minimum.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Wasteload Allocations*: None. NPDES permit 10064 has been determined to sufficiently address nutrient issues. See Appendix B. *Load Allocations:* Same as temperature.
Margin of Safety *CWA 303(d)(1)*	*Implicit margin of safety: Conservative* assumptions in modeling.
WQS Attainment Analysis *CWA 303(d)(1)*	• Statistical demonstration of pH relationship to current stream temperature conditions. • Analytical assessment of simulated temperature change related to allocated solar loading.
Public Participation (40 CFR 25)	***See page 63 of the WQMP in addition to information contained herein.***

5.1 APPLICABLE WATER QUALITY STANDARDS

Please see the beginning of the section on temperature standards for a discussion of how water quality standards are developed.

PH (OAR 340-041-0285 (2)(d)(A))

"Fresh waters (except Cascade Lakes) and estuarine waters: pH values shall not fall outside the range of 6.5 to 8.5."

In the Little River Watershed, analysis has established that pH is closely linked with temperature, and as temperature is decreased, pH will meet the standard.

5.2 PH ASSESSMENT

A stream is listed as water quality limited if there is documentation that greater than 10 percent of the samples exceed the standard and a minimum of at least two exceedances of the standard for a season of interest. The season of interest is June 1 through September 30.

Many chemical and biological processes in a stream are affected by pH. The standard for pH values indicates the lower and upper limits that protect most aquatic species in western Oregon. Values outside of this range (within which salmonid fish species evolved) may result in toxic effects to resident fish and aquatic life (EPA 1986). When pH is outside this range, it can reduce the diversity of aquatic organisms in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. However, the effects of elevated pH on wild fish in a "natural" system have not been determined. The highest known documented juvenile steelhead trout densities on the Umpqua National Forest occur in a reach of stream with a pH as high as 8.9.

Stream pH values are greatest in the afternoon, an indirect result caused by the consumption of carbon dioxide during photosynthesis (Stumm and Morgan 1981). Photosynthesis and aquatic plant growth follow yearly and diurnal cycles, which in Little River are greatest during summer afternoons. The highest stream water pH values correspond to these periods of maximum photosynthesis. Conversely, pH values tend to be lower during the early morning hours and during the winter. Photosynthetic activity in dense algae mats can cause carbon depletion in the water column by taking up dissolved carbon dioxide faster than the atmosphere can replenish it. As carbon depletion progresses, there is an increase in pH as the equilibrium between dissolved carbon dioxide (CO2), bicarbonate (HCO-3) and carbonate ions (CO3-2) moves towards carbonate.

Streams high in carbonates have a natural buffering capacity to dampen diurnal variations in pH attributable to photosynthesis and depletion of carbon dioxide. However, most western Oregon streams are low in alkalinity (carbonates), and many streams have pronounced diurnal pH swings. The US Geological Survey (1996) reported a single alkalinity value of 51 mg/l ($CaCO_3$) near the mouth of the Little River. Powell (1996) reported lower alkalinity at sites higher in the watershed (Powell and Rosso 1996). A median alkalinity value of 28 mg/l ($CaCO_3$) was reported by U S Geological Survey (1996) for the North Umpqua basin.

POSSIBLE CAUSES OF HIGH pH

High summertime stream pH values in Little River probably result from algae growth due to the combined effects of the following:

1. Inadequate stream surface shading;
2. Increased nutrient inputs above background levels due to forest, agricultural, and residential land uses which may indirectly have an effect on pH (MacDonald et al 1991);
3. Increased channel scouring caused by increased peakflows from timber harvest units and roads;
4. A deficiency of large wood in the active channel; and
5. Natural events and naturally occurring high pH values.

Elevated nutrient inputs from forest and agriculture land use, poorly sited or faulty septic systems, and sewage treatment system discharges can promote primary production (algae growth) and elevated pH levels. Chemical fertilizers applied to commercial forest lands, agricultural areas and residential yards may be nonpoint sources of nutrients. While studies are currently underway, at this time no ambient data is available to definitively assess the effects of fertilizer application on water quality.

The Wolf Creek Conservation Center represents the only surface water point source discharge in the Little River Watershed.

Reduced stream surface shade has been shown to increase pH by encouraging photosynthetic chemical reactions associated with plant growth (DeNicola et al. 1992). Increased algal productivity in response to increased solar exposure has been well documented (Gregory et al. 1987, DeNicola et al. 1992).

High wintertime peak flows often scour streambeds, creating channel bottoms dominated by bedrock and/or large grained substrate, on which algae prefer to attach and grow. Bedrock stream reaches, commonly found in the Little River, provide favorable habitat and surface area for algae and poor habitat for algae-eating aquatic insects. Ditches along roads that concentrate and funnel water to streams can increase peak flows.

Channel simplification may also promote algal growth and accumulations. Harvest of streamside trees limits recruitment of large wood to the channel and floodplain. Powell (1996) suggests that poor woody debris recruitment can potentially increase pH. Large woody debris plays an important role in shaping stream channel complexity and bed form. Streams with a deficiency of large woody debris offer poor habitat for grazing macroinvertebrates (aquatic worms, snails, crustaceans and insects) that eat algae.

Natural processes that may elevate stream pH include floods, fires, insect damage to vegetation, diseased vegetation, and wind throw in riparian areas. These natural processes affect stream pH by increased nutrient loads delivered to the stream, increased solar exposure, and streambed scouring. Little River may also have naturally-occurring high pH levels due to geology and the lack of connectivity between flood plain and riparian areas, which may affect the buffering capacity of riparian areas.

DATA REVIEW

The availability of nutrients such as nitrogen and phosphorus can limit algae growth rates and photosynthesis. Inorganic nitrogen concentrations are very low in the North Umpqua River above the Little River confluence. US Geological Survey (1996) data indicate that inorganic nitrogen concentrations were undetectable (<5 ug/l) at most monitoring locations. In a single sample, collected near the mouth of Little River, ammonia and nitrate were below the levels of detection (<2 ug/l and 1 ug/l, respectively) (USGS 1996).

Nitrogen is likely to be taken up by the algae immediately upon entry into the stream rather than to remain in the water column; therefore, water column measurements may not accurately portray nitrogen concentrations. Total phosphorus and soluble reactive phosphorus concentrations were 7 ug/l and 1 ug/l, respectively. The US Geological Survey (1996) reported that soluble reactive phosphorus concentrations were relatively plentiful elsewhere in the North Umpqua basin with median concentrations greater than 20 ug/l. Little River data and information collected elsewhere in the North Umpqua basin indicate that the availability of nitrogen highly affects the production of algae. This is additional evidence that the system is nitrogen-limited with sufficient phosphorus present to sustain growth when nitrogen is introduced.

Observed total and orthophosphorus, pH, and temperature data, all factors that influence periphyton growth, are reviewed below. Much of the reviewed data were used as inputs to a pH (carbon balance) model used to determine the TMDL (See Appendix B).

Phosphorus

On August 29 – 31, 2000, DEQ conducted an intensive survey of orthophosporus in Little River. Orthophosphorus (soluble phosphorus), the most readily available form for periphyton growth, was collected at several sites on the Little River. **Table 9** lists the data collected during the survey that were used as pH model inputs:

Table 9. Little River Orthophosphorus (August 29-31, 2000)

MONITORING LOCATION	Orthophosphorus (mg/L)
Little River below Pinnacle Cr. (RM 25.3)	0.027
Little River below Clover Cr. (RM 21.0)	0.026
Little River above E. Mile Cr. (RM 14.7)	0.020
Little River above Wolf Cr. (RM 8.0)	0.016
Little River @ Mouth (RM 0.6)	0.008

pH

Single afternoon samples collected by US Geological Survey staff in the Little River in July, 1995 found stream pH values near or above the water quality standards. Values of 8.1, 8.6, and 8.4 and 8.3 were measured near Black Creek, above Wolf Creek, and at the mouth of the Little River, respectively (U. S. Geological Survey Draft report 1996). The stream pH values recorded earlier in the day were well within water quality standards. Measurements taken for the Umpqua National Forest in August 1994, indicated afternoon pH levels exceeding numerical criteria in the lower 18 miles of the Little River mainstem, as shown in Figure 10 below (Little River Watershed Analysis 1995).

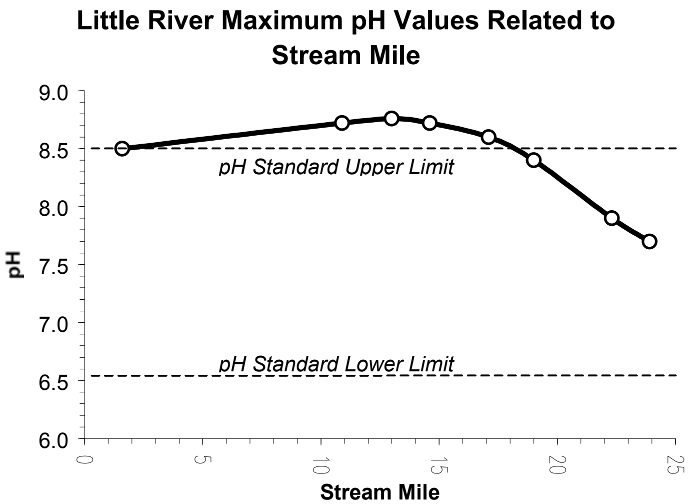

Figure 10. Little River pH values related to stream mile.

Continuous pH data was collected during the August, 2000 intensive survey. Maximum daily pH data collected on August 30 were used as input and used as calibration points in the pH model. The pH standard of 8.5 was exceeded at the rivermile 14.7, 8.0 and 0.6 monitoring locations. The pH data collected at rivermile 0.6 should be considered questionable due to instrument malfunction during a portion of the study period. The data are detailed in **Table 10**:

Table 10. Little River pH Data (August 29-31, 2000)

MONITORING LOCATION	pH [-LOG H+]
Little River below Pinnacle Cr. (RM 25.3)	7.7
Little River below Clover Cr. (RM 21.0)	8.3
Little River above E. Mile Cr. (RM 14.7)	**8.6***
Little River above Wolf Cr. (RM 8.0)	**8.8***
Little River @ Mouth (RM 0.6)	**8.6***

*** Data exceeds state of Oregon pH standard.**

Temperature

The observed continuous data collected during August 2000 indicates that the temperature of Little River steadily increases from upstream to the mouth. The data, which were used as pH model inputs, are included in **Table 11** below:

Table 11. Little River Maximum Temperatures (August 29-31, 2000)	
MONITORING LOCATION	**TEMPERATURE Degrees C. (Degrees F.)**
Little River below Pinnacle Cr. (RM 25.3)	15.2 (59.4)
Little River below Clover Cr. (RM 21.0)	15.6 (60.0)
Little River above E. Mile Cr. (RM 14.7)	17.7 (63.9)
Little River above Wolf Cr. (RM 8.0)	19.2 (68.6)
Little River @ Mouth (RM 0.6)	22.0 (71.6)

A regression analysis of pH and stream temperature, using continuous data collected on August 30, 2000, by DEQ, illustrates the pH of the Little River at rivermile 14.7 (**Figure 11**). The regression analysis ignores other factors, such as the effect that nutrients and light have on algal growth, and subsequently pH. Nonetheless, it illustrates an association between pH and stream temperature.

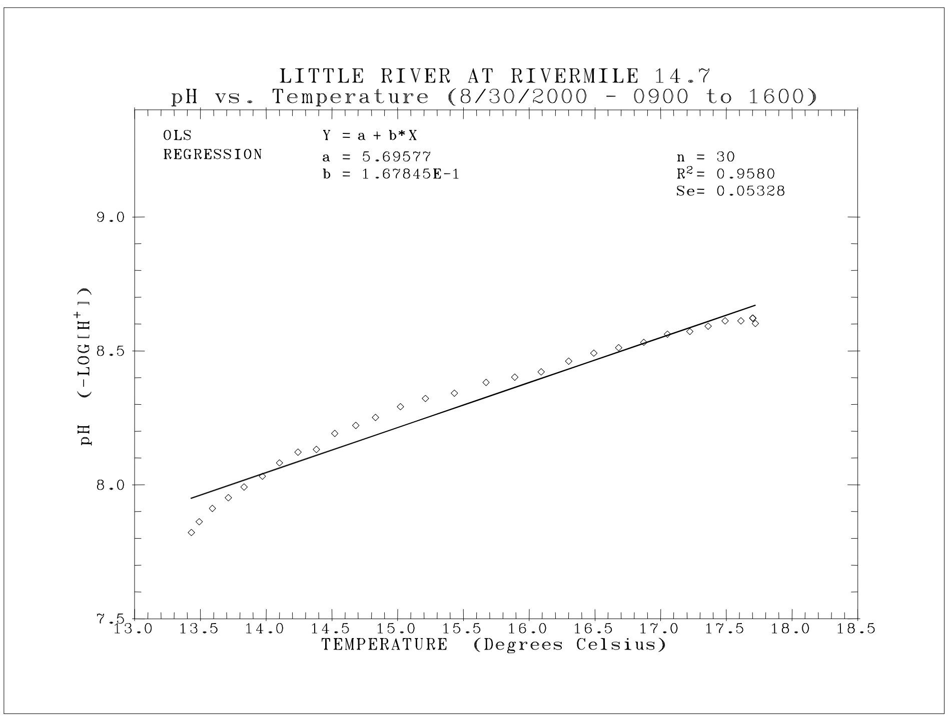

Figure 11. Regression Analysis of pH and Stream Temperature at Rivermile 14.7

The increase in Little River temperature coincides with the increase in periphyton growth and pH. It appears from this data review that the key to reducing periphyton growth and meeting the goal of stream pH below 8.5 SU is to reduce stream temperature.

Figure 12 represents the theoretical relationship between stream temperature and algal growth. The algal growth rate increases significantly as stream temperature increases.

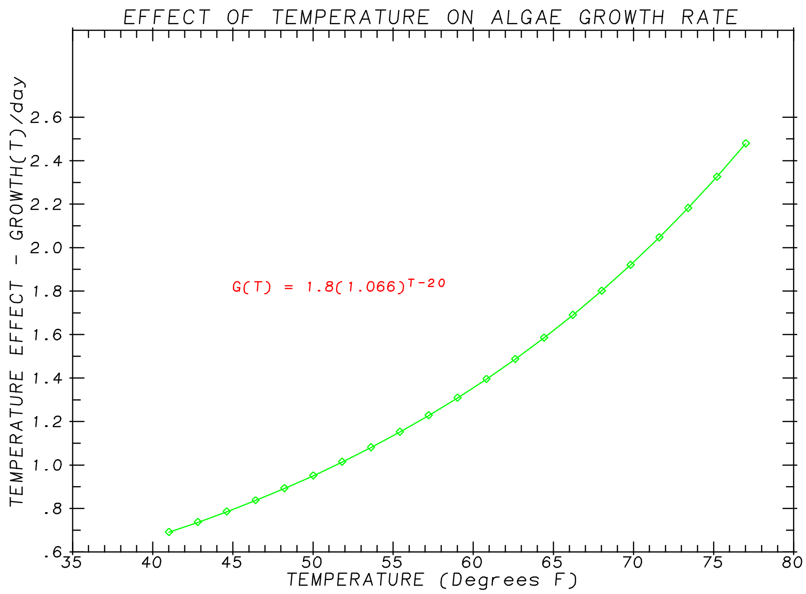

Figure 12. The Theoretical Relationship between Stream Temperature and Algal Growth

5.3 Pollutant

Nutrients, pH and temperature data indicate that reducing stream temperature is the key to reducing excessive periphyton growth and pH fluctuations in the river. Since phosphorus concentrations are above what could be considered limiting in the upper reaches of Little River, there does not appear to be adequate opportunity to reduce phosphorus loads to a level that would have a significant impact on either periphyton growth or pH.

A model (discussed in Appendix B) was developed to further investigate the relationship between temperature and pH. The model corroborates the association seen in the pH and temperature data collected at rivermile 14.7. The model predicts that the pH standard will be achieved through the implementation of the system potential temperature TMDL allocations.

Solar heat energy is the pollutant that is the focus of this pH TMDL.

5.4 Regulatory Framework

Under the current regulatory framework for development of TMDLs, identification of the loading capacity is an important first step. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. By definition, TMDLs are the sum of the allocations [40 CFR 130.2(i)]. Allocations are defined as the portion of a receiving water's loading capacity that is allocated to point or nonpoint sources and natural background. EPA's current regulation defines loading capacity as "*the greatest amount of loading that a water can receive without violating water quality standards*."

5.5 pH LOADING CAPACITY

As discussed in the data review, a water quality concern in Little River from rivermile 14.7 to the mouth is pH exceeding the State of Oregon water quality standard (greater than 8.5 standard pH units (SU)). The presence of instream aquatic plants can have a profound effect on the variability of pH throughout a day and from day to day. In the Little River, the emphasis is on attached algae (periphyton) which cling to rocks and other substrate. Nitrogen, phosphorus, light availability, and stream temperature are all parameters necessary for supporting periphyton growth. The data review indicates there is little reason to believe that nutrients can be reduced to concentrations needed to limit algal growth in the Little River.

The rate of periphyton growth is limited by the availability of light, nutrients, and water temperature. In a situation where the available light for periphyton growth is at an optimum level and nutrients are plentiful, then the growth of periphyton will be dependent on the temperature effect (Thomann and Mueller, 1987).

The data review also indicates that the increase in pH is correlated with the increase in stream temperature at rivermile 14.7. Both the regression analysis of pH versus temperature and a pH model of Little River (rivermile 25.3 to 0.6) predict that the instream pH will be maintained below the standard (8.5 SU) when system potential temperature TMDL allocations and the resulting stream cooling are achieved.

The temperature model of Little River (Appendix A) predicts current management potential temperatures of 16.0, 17.0 and 17.0 degrees Celsius at rivermiles 21.0, 14.7, and 8.0, respectively. The pH/temperature regression and the pH model predict that the maximum instream pH at rivermile 14.7 will be approximately 8.4 SU and achieving the pH standard when the river achieves current management potential temperatures.

The loading capacity for this TMDL is the system potential stream temperatures as predicted in Chapter 4, or 146,529,885.6 kilocalories per day.

5.6 LOAD ALLOCATIONS

It was determined by the above pH modeling of Little River that achieving the load allocations established for temperature will reduce periphyton growth and lead to the attainment of the water quality standards for pH. Refer to Chapter 4.75 of the temperature TMDL for allocations.

The temperature TMDL allocations established in Chapter 4 are the allocations for this TMDL.

5.7 POINT SOURCE EVALUATION / WASTELOAD ALLOCATIONS

The Umpqua National Forest operates an extended aeration wastewater treatment plant with filtration at Wolf Creek Conservation Center (NPDES permit 10064). This facility discharges year round to the Little River at river mile 12.75. A review of the Discharge Monitoring Reports (DMRs) for the period of June 1999 through July 2000 indicates that the average monthly effluent flow from this facility is 0.018 million (18,000) gallons per day, although it has been as high as 22,000 gallons per day in the past. The DMRs indicate that the facility has been complying with the NPDES permit limits of BOD5, TSS, pH, and fecal coliform bacteria, as allowed in the NPDES permit. Discharges from Wolf Creek Conservation Center into the Little River have been analyzed and determined to have no measurable effect on summertime stream temperature, stream pH, sedimentation, or habitat modification.

Dilution estimations were made with monthly DMRs and Little River 7Q10 flows calculated from the U. S. Geological Survey gage record downstream at Peel (Station Identification Number 14318000). A 7Q10 receiving stream flow to effluent ratio of approximately 380:1 was calculated. (7Q10 is a statistical measure of the streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval, or 1 in 10 chance of occurring in any given year. Daily stream-flows in the 7Q10 range are general indicators of prevalent drought conditions which normally cover large areas.)

DEQ conducted a mixing zone study on July 15, 1997 to assess effluent quality and mixing characteristics in the Little River. Ambient samples were collected upstream and downstream of the wastewater treatment plant. Final effluent samples were also collected for analysis at that time. Field and laboratory results are shown in Table 12, with averages for June 1999 to July 2000 based on DMRs shown in parentheses following the 1997 figures for BOD, TSS, and fecal coliform bacteria.

No changes in ambient stream temperature, pH, dissolved oxygen, or nutrient concentrations were recorded in the Little River below the wastewater treatment plant, although the upper pH criterion of 8.5 was exceeded at all three ambient sampling locations. Ambient stream data collected in Little River indicate that nitrogen was likely limiting algal productivity upstream and downstream of the wastewater treatment plant. Ammonia nitrogen was relatively abundant in the stream although less so than ortho-phosphate.

In 1997, ammonia nitrogen in the final effluent was as high as 22 mg/l but the large stream-to-effluent dilution ratio of 380:1 minimized any adverse effects outside of the defined mixing zone. The plant is currently operating under a management plan that allows nitrification to occur during most of the summer season, which reduces ammonia nitrogen concentrations, thus reducing any adverse effects. There have been no known violations of any permit limits through the year 2000.

Little River Christian Camp is noted in some reports as a point source. For an undetermined period of time ending in 1995, there was a direct discharge from this facility when the drainfield failed and there was overland flow of sewage directly into the River. However, several years ago the drainfield situation was remedied and a recirculating gravel filter installed so there is no longer any direct discharge to the stream. This onsite disposal system is operated under the state’s Water Pollution Control Facility (WPCF) permit program, which is for systems without any direct discharge. The WPCF permit requires periodic monitoring and maintenance to ensure the facility is operated properly. Consequently, this facility is not considered a source of nutrients.

There are other water pollution control facilities elsewhere in the basin, which may be considered potential sources of nitrogen and phosphorus. It is estimated that there are 90 septic systems scattered throughout the lower watershed, based on the number of domestic water rights issued by the state. Many of these systems were installed years or decades before DEQ began onsite system inspections and its permitting process. Improperly located systems, older systems, and poorly maintained systems may contribute nutrients to portions of the Little River system where pH violations have been measured. Currently there is no required monitoring or inspection of septic systems once installed, and the effect these sources have on water quality is unknown. However, DEQ records show that 39 systems underwent repair in the past ten years, suggesting that some of the potential impacts have been eliminated or minimized.

Table 12. Wolf Creek Sewage Treatment Plant (STP) Water Quality Data (1997 data except 1999-2000 data in parentheses)

Parameter / Sampling Site	Little River Above Wolf Creek STP	Wolf Creek STP Final Effluent	Little River Below Wolf Creek STP	Little River at Wolf Creek Bridge (>1 Mile Below Wolf STP)	Little River at Wolf Creek Bridge (QA) (>1 Mile Below Wolf Creek STP)
Field Temperature (°C)	22	-	22	22	22
Field pH	8.8	6.7	8.8	8.7	8.7
Ammonia as N (mg/l)	0.04	22	0.05	0.04	0.05
Nitrate and Nitrite as N (mg/l)	<0.02	1	<0.02	<0.02	<0.02
Total Kjeldahl N (mg/l)	<0.2	23	<0.2	<0.2	<0.2
Ortho Phosphate as P (mg/l)	0.017	0.408	0.017	0.016	0.017
Total Phosphate as P (mg/l)	0.02	0.44	0.02	0.02	0.02
BOD (mg/l)	0.8	6 (2)	<0.1	0.2	<0.3
COD (mg/l)	<5	16	<5	<5	<5
TOC (mg/l)	1	8	<1	<1	<1
TS (mg/l)	57	270	59	-	-
TSS (mg/l)	<1	<1 (1)	1	-	-
Turbidity (NTU)	1	1	1	-	-
DO Saturation (%)	97	-	97	99	97
DO by Winkler Titration (mg/l)	8.6	0.2	8.6	8.7	8.6
E. Coli by Membrane Filtration (CFU/0.1L)	<4	20	<4	8	-
Fecal Coliform By Membrane Filtration (CFU/0.1L)	<4	100 (3)	<4	8	-

5.8 IMPLICIT MARGIN OF SAFETY - PH

The following comprise the margin of safety implicit in the determination of the pH TMDL:

- A conservative half-saturation constant was used in the model (0.004), which is at the lower end of the literature range for algae (EPA, 1985).
- The pH model does not estimate the potential effects of grazing by macroinvertebrates on the periphyton crop. Grazing may influence not only the standing crop, but also nutrient uptake and recycle rates, as well as species distribution within the benthic algal mat. Grazing generally results in lower periphyton biomass (Lamberti, et al., 1987 and Welch, et al., 1989), a simplified algal community, lower rates of carbon production, and constrained nutrient cycling (Mulholland, et al., 1991). Reduced algal production rates under the temperature management strategy will likely increase the relative influence of grazing as a controlling mechanism on periphyton.
- Because photosynthesis responds quantitatively to changes in light, environmental variation in its quantity and quality potentially account for much of the variation in the physiology, population growth, and community structure of benthic algae (Stevenson, Bothwell, and Lowe, 1996). In addition to reducing periphyton growth through cooling the river, the

additional shading of the river resulting from the implementation of the temperature TMDL will help reduce light availability, which may help the river shift from a dominance of nuisance filamentous green algae species (e.g., Cladophora) to single cell species (e.g., diatoms).

- The margin of safety in the temperature TMDL applies to the pH TMDL.

- pH modeling was based on temperatures generated by the current management potential scenario. Future temperatures are likely to be below this and provide an additional margin of safety.

5.9 SEASONAL VARIATION AND CRITICAL CONDITIONS

For pH, the period of concern is the summer, when high stream temperatures are associated with pH levels above the water quality standard. Stream temperatures are highest during the summer, and are closely associated with high pH levels. Modeling was done using 7Q10 flows, a measure associated with very low flows and, therefore, relatively little dilution. The modeling conditions represent critical conditions for pH.

6. SEDIMENT TMDL

Table 13 below summarizes the components of the sediment TMDL:

Table 13. Little River Watershed Sediment TMDL Components

State/Tribe: Oregon

Waterbody Name(s): All perennial streams within the 5th field HUC (hydrologic unit code) 1710030111– Little River Watershed, Mouth to headwaters.
Point Source TMDL:_____ Nonpoint Source TMDL: X (check one or both)

Date: January, 2001

Component	*Comments*
Pollutant Identification	"Sediment" *Pollutant:* Sediment *Anthropogenic Contribution:* Excess inputs of fine sediments
Target Identification *CWA 303(d)(1)* *40 CFR 130.2(f)*	*Applicable Water Quality Standards:* **Sediment (OAR 340-041-0285 (2)(J))** The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed. *Loading Capacity:* 405 tons of sediment per square mile per year.
Existing Sources *CWA 303(d)(1)*	*Anthropogenic sources of sediment:* • Surface Erosion from Roads • Ditches accelerating peak flows • Road/stream crossings • Increased peak flows and bank erosion from timber harvest • Increased surface erosion from timber harvest and agriculture • Increased mass wasting from timber harvest • Bank erosion from agricultural activities
Seasonal Variation *CWA 303(d)(1)*	*Time period of interest:* All year. Sediment inputs are dependent on quantity and intensity of precipitation, so winter is the time of maximum sediment inputs and movement of sediments through the system. Impacts from sediment, however, are yearlong.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Wasteload Allocations*: None. *Load Allocations:* 195 tons of sediment per square mile per year. *Numeric Targets:* Instream and hillslope numeric targets.
Margin of Safety *CWA 303(d)(1)*	*Implicit Margin of Safety:* Conservative assumptions in modeling.
WQS Attainment Analysis *CWA 303(d)(1)*	• Sediment budget analysis identifies management-related increases in sediment inputs as compared to reference conditions; • Studies support assumption that management-related sediment inputs are 70% controllable; • 70% reduction in management-related sediment inputs will result in sediment levels within the range of uncertainty for background levels.
Public Participation (40 CFR 25)	***See page 63 of the WQMP in addition to information contained herein.***

6.1 APPLICABLE WATER QUALITY STANDARDS

Please see the beginning of the section on temperature standards for a discussion of how water quality standards are developed.

SEDIMENT (OAR 340-041-0285(2)(j))

"The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed."

Sediment listings in the Little River Watershed are based on findings of large amounts of fine sediment in portions of Little River and Cavitt Creek, as identified by the Little River Watershed Analysis completed by the federal agencies in 1995.

Because the standard is in narrative form, additional criteria were developed by DEQ to assess when a stream should be placed on the 303(d) list for sediment. These are the criteria used to establish listings for sediment on Oregon's 1998 303(d) list:

> **WATER QUALITY LIMITED CRITERIA: Documentation** that sedimentation is a significant limitation to fish or other aquatic life as indicated by the following information:
>
> > Beneficial uses are impaired. This documentation can consist of data on aquatic community status that shows aquatic communities (primarily macroinvertebrates) which are 60 % or less of the expected reference community **for both** multimetric scores and multivariate scores are considered impaired. Streams with either multimetric or multivariate scores between 61% and 75% of expected reference are considered streams of concern. Streams greater than 75% of expected reference communities using either multimetric or multivariate models are considered unimpaired.
>
> -or-
>
> > Where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity, or similar metric rating of poor or a significant departure from reference conditions utilizing a suggested EPA biomonitoring protocol or other technique acceptable to DEQ.
>
> -or-
>
> > Fishery data on escapement, redd counts, population survey, etc. that show fish species have declined due to water quality conditions; and documentation through a Watershed Analysis or other published report which summarizes the data and utilizes standard protocols, criteria and benchmarks (e.g., those currently accepted by Oregon Department of and Wildlife or federal agencies (PACFISH). Measurements of cobble embeddedness or percent fines are considered under sedimentation. Documentation should indicate that there are conditions that are deleterious to fish or other aquatic life.

TIME PERIOD: Annual

DATA REQUIREMENTS: Data collected since Water Year 87 (10/86) and included in the most recent Watershed Analysis or published report. Earlier data will be considered on a case by case basis.

While these listing criteria allow a determination of whether or not an impairment exists, they are not sufficient in terms of load allocation development. For that reason, additional numeric targets had to be developed for this TMDL.

NUMERIC TARGETS

The numeric targets developed for the Little River TMDL are intended to parallel the values noted in the narrative standard. Values indicated are not intended to bring enforcement action based on instream numeric target exceedances. (Redwood Creek Sediment TMDL 1998)

Numeric targets interpret existing narrative water quality objectives in order to:

- describe physical conditions of streams in the Little River Watershed and the hillslopes around the streams which are associated with attainment of the narrative objectives and beneficial uses;
- assist in estimating the streams' capacity to receive future sediment inputs and still support beneficial uses;
- compare existing and target conditions for sediment related factors;
- provide an evaluation framework for analyzing monitoring data collected in the future and making changes in the TMDL and /or WQMP in response; and
- assist in evaluating whether land management and restoration actions are effective in adequately reducing erosion and subsequent sediment loading to the streams.

INSTREAM NUMERIC TARGETS

Instream numeric targets, as included in this TMDL, represent adequate stream habitat conditions for salmonid reproductive success and system potential macroinvertebrate community diversity. Instream targets provide a vital set of measures of whether, in the long run, beneficial uses impacted by sedimentation are recovering.

The indicators for which DEQ is establishing instream numeric targets are as follow:

- percent fines<0.85 mm;
- percent fines <6.5 mm;
- median surface particle size (d50);
- macroinvertebrate indices; and
- residual large wood.

Fine sediment targets are intended to apply in fish bearing reaches of generally low gradient (<3% slope). Scientific literature suggests that these indicators are the most easily linked to fish and macroinvertebrate habitat conditions and can assist in evaluating long term impacts of hillslope erosion and erosion reduction efforts (Knopp 1993, Chapman 1988, Peterson et.al. 1992, NMFS 1997). The targets are monitoring and evaluation goals intended to represent the desired condition where sediment is not a limiting factor for salmonid and macroinvertebrate production.

The numeric targets are based on scientific literature, available monitoring data and best professional judgment. The targets parallel those selected by the EPA for the sediment TMDL for Redwood Creek, California, and reference is made to that document for additional references relating to the numeric targets. When implemented, the TMDL should fully meet these targets and as a result attain the water quality standard. **Table 14** depicts the instream numeric targets.

Table 14. Instream Numeric Targets for Little River Watershed Streams	
Parameter	**Numeric Targets (Desired Condition)**
Percent fines < 0.85 mm in riffle crests of fish bearing streams	< 14%
Percent fines < 6.5 mm in riffle crests of fish bearing streams	< 30%
Median particle size diameter (d50) from riffle crest surfaces	= 37mm (minimum for a reach) = 69 mm (mean for a reach)
Macroinvertebrate indices	Expected reference community
Large woody debris in watercourse	Improving trend towards increased large woody debris

HILLSLOPE TARGETS

Hillslope targets represent desired conditions for land management, which are associated with properly functioning erosional processes and erosion rates that are not excessively accelerated by human influences. If these hillslope target conditions are attained, erosion rates and sediment delivery to streams should decline to levels that allow Little River Watershed stream habitat to recover from the effects of excessive sedimentation that occurred in the past. Recovery from these effects may take many years. Hillslope targets provide an immediately useful set of measures of whether land uses known to contribute much of the human caused share of sediment loading to Little River streams are being modified in ways which will minimize future erosion potential and sediment delivery. **Table 15** depicts the hillslope targets.

Table 15. Hillslope Targets for Little River (from WQRP, Appendix C)	
Parameter	**HillslopeTargets (Desired Conditions)**
Road/stream crossings: Diversion potential: Culvert size: Ditch length:	 No crossings have diversion potential. All culverts are sized to pass 100-year flood and associated sediment and debris. Install cross drains to reduce ditch length at all stream crossings.
Road location in riparian, inner gorge or unstable headwall areas	No future roads are located in riparian steep inner gorge or unstable headwall areas except where alternatives are unavailable. [1]
Road fill, cutslope, surface and drainage	All roads have surface and drainage facilities or structures that are appropriate to their patterns and intensity of use. All unstable landings and road fills [2] that could potentially deliver sediment to a stream are pulled back and stabilized.
Use of clear-cut and/or ground based timber harvest	Future harvesting avoids steep inner gorge, unstable or streamside areas unless a detailed assessment is performed which shows there is no potential for increased sediment delivery to streams as a result. [3]
Peak flows	Consider peak flows and hydrologic recovery when planning timber harvest to maintain appropriate canopy closure.
Large woody debris	LWD in streams mimics natural conditions. Reintroduce fire into ecosystem.

[1]According to the Watershed Analysis, unstable landings and road fills are generally those that are located on slopes >60%.

[2] Steep inner gorge areas generally exceed 65% in slope and are located adjacent to class 1 or 2 streams. Characteristics of steep, unstable headwall areas generally include the following (Redwood Creek TMDL, 1998):
-slopes > 50%
-erosive or incompetent soil type or underlying geology
-concave slope shape
-convergent groundwater present and/or evidence of past movement is present

[3] Characteristics of steep inner gorge, unstable, or streamside areas generally include the following (Redwood Creek TMDL, 1998):
-slopes > 50%
-located within 300 feet of a class 1, 2, or 3 stream
-erosive or incompetent soil type or underlying geology
-concave slope shape
-convergent groundwater present and/or evidence of past movement is present

6.2 Problem Statement

The basis of the 303(d) listings for sediment in the Little River was the impact on salmonid species, including endangered coho, of excessive fine sediment. The conditions and their impacts were documented in the 1995 Little River Watershed Analysis, conducted by the Umpqua National Forest and the Roseburg District of the Bureau of Land Management. As discussed in the Watershed Analysis, the cumulative sediment impacts to fish and aquatic life from management activities appear to be widespread in the watershed. The stream segments identified as water quality limited for sediment on the 1998 303(d) list are shown in **Figure 13** below:

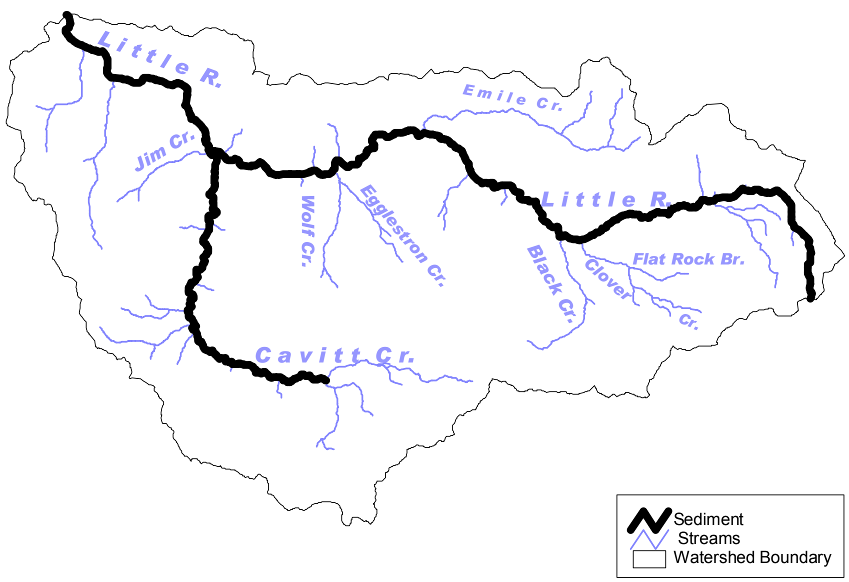

Figure 13. Stream segments listed on the 303(d) list for sediment

The Watershed Analysis data in support of the listings included aquatic insect assemblages from several sample locations in the watershed. Aquatic insects are sensitive to changes in aquatic habitat and are often used to assess the quality of habitat conditions. Aquatic insects serve as the primary food source for fish and play an important role in stream ecology. The richness and variety of macroinvertebrate species are affected by excessive sedimentation because sediment may fill the interstices between coarser substrate, reducing available habitat.

Macroinvertebrate sampling was analyzed by grouping the subwatersheds into "vicinities." The various vicinities in Little River are shown in **Figure 14**:

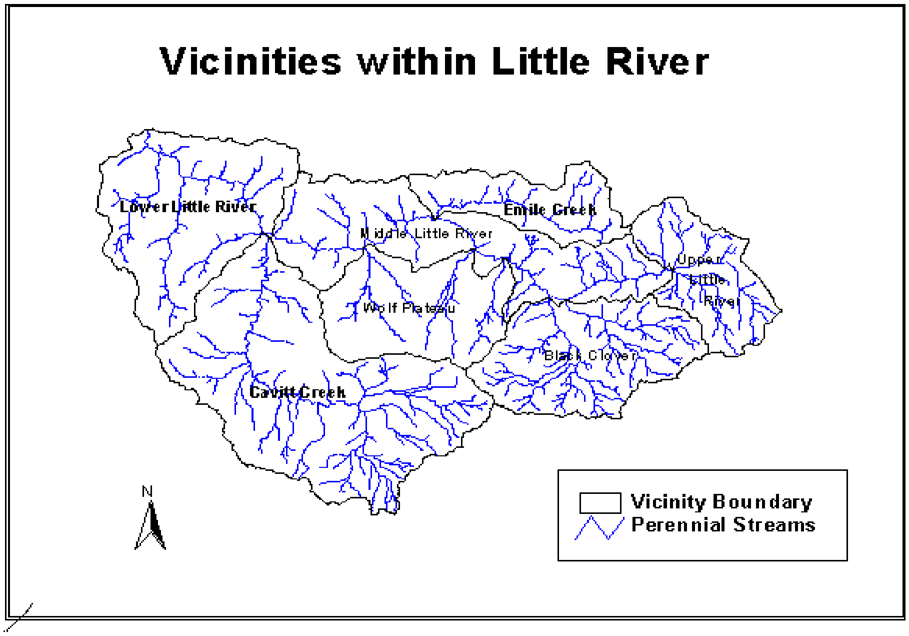

Figure 14. Vicinities Within Little River

The general assemblage of taxonomic types identified at sample locations in the Little River Watershed indicated populations impacted by stressors, some of which were thought to be increased amounts of sediment in gravel riffles sampled. The analysis of the data for each "vicinity" sampled is shown in **Table 16**:

Table 16. Summary of US Forest Service Aquatic Insect Samples Collected in 1994 (Little River Watershed Analysis 1995)

Vicinity	Sample Site	Overall Condition of Macroinvertebrate Community
Lower Little River	Near Mouth	Fair to poor. Low richness in mayfly: stonefly: caddis fly populations indicates impaired habitat/water quality. Numerous aquatic worms suggest an abundance of ***fine sediment.***
Middle Little River	Above Cavitt Creek	**Fair to poor.** Similar to Lower Little River site.
Middle Little River	Near Negro Creek	**Fair.** High richness in mayfly, stonefly, caddis fly populations indicates good habitat/water quality. Also, abundance of tolerant snails, black flies, and crane flies which are tolerant of excessive filamentous algae and/or disturbed enriched streams.
Cavitt	Near mouth	**Fair.** Moderate to low richness in mayfly, stonefly, caddis fly populations, but some highly sensitive species not tolerant of certain degraded habitat conditions also found. Moderate black fly numbers indicate somewhat depressed habitat or water quality.
Cavitt	Upper (above Cultus Creek)	**Moderate to good.** High richness in mayfly, stonefly, caddis fly populations with several sensitive species corresponds to high habitat complexity and integrity. A few tolerant species also found indicating perhaps declining habitat or water quality.
Emile	0.35 u/s of mouth	**Fair.** Low richness in mayfly, stonefly, caddis fly populations with only a few sensitive species found. Aquatic worms and dragonflies tolerant of warm water, ***fine sediment*** and low dissolved oxygen present.
Black Clover	0.25 mile u/s of mouth of Clover Creek	**Fair.** Low to moderate richness in mayfly, stonefly, caddis fly populations; however, several sensitive species found that prefer cool water and won't tolerate fine sediments and high winter scour or gravel resorting. Moderate numbers of tolerant caddis flies also found pointing to a general decline in habitat or water quality.
Black Clover	0.25 mile u/s of mouth of Black Creek	**Fair to poor.** Low richness in mayfly, stonefly, caddis fly populations with very few sensitive species found. Moderate numbers of tolerant dragonflies, snails, caddis flies, and aquatic worms. Usually indicative of high summer water temperatures, nutrient enrichment, sediment input and/or low flows.

In addition to the impacts on aquatic macroinvertebrate communities, the Watershed Analysis cited reduced spawning success of salmonid species indicated by an abundance of early emergence of sac-fry (larval fish) from spawning gravels. The data were collected from out-migration in a rotary screw trap, operated from 1995 to 2000, about 5-6 miles from the confluence with the North Umpqua River. In addition, there was visible evidence of large amounts of fine sediment in spawning gravels.

Increased sedimentation may cause sac-fry to emerge prematurely from the spawning gravels. Studies have shown that sac-fry are often forced out of the gravel before they have absorbed their yolk sacs, greatly reducing their survival. Fine sediments fill the interstitial pore spaces of the redd, resulting in a lack of intergravel dissolved oxygen needed for the sac-fry (Tappel and Bjornn 1993).

While there were other hypotheses as to the cause of early emergence of sac-fry, such as disturbance from steelhead spawning activity in the area of the redds, no evidence was found to support such a link. Nor were storm events or high temperatures factors in the early emergence of sac-fry. (Watershed Analysis 1995, p. 12)

Increased winter peak flows result in intensified water velocity in channels, eroding stream banks and modifying channel morphology. Exposure to the stresses of these exacerbated peak flows likely lowers over-winter survival of juvenile salmonids. The hillslope numeric targets in Table 15 above include peak flows.

Loss of pool frequency and pool area may also result from sedimentation. Although it is difficult to directly link a particular sediment source with a specific pool, studies indicate excessive sedimentation may play a role in reducing pool depth and frequency (Lisle and Hilton, 1992).

6.3 SEDIMENT SOURCES (SOURCE LOADING)

INTRODUCTION: GEOGRAPHIC AND GEOLOGICAL DESCRIPTION

The Little River Watershed lies within the North Umpqua subbasin and drains portions of the Western Cascade Range, the Klamath Range and the Coast Range (**Figure 14**). As noted earlier, sixty-three percent of the land in the watershed is administered by USDA Forest Service and USDI Bureau of Land Management.

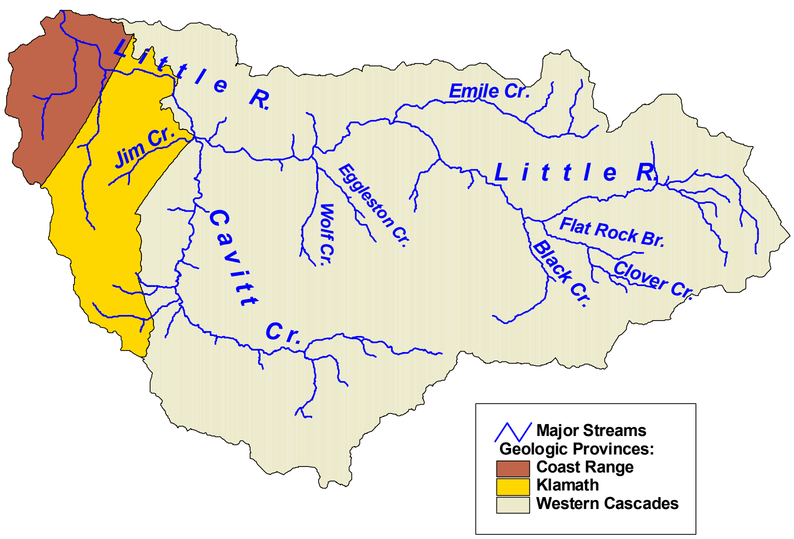

Figure 15. Geologic provinces in the Little River Watershed

Much of the watershed (83%) lies within the Western Cascades geologic province, while the Klamath and Coast Range geologic provinces account for 11% and 6% of the watershed (Little River Watershed Analysis 1995). The geomorphic processes of surface erosion, fluvial (stream-related), and landslides (mass wasting) are natural cyclic processes that strongly influence sediment production and delivery in Little River. The mass movement of soil is a major component of hill slope erosion and sediment transport in streams in mountainous terrain. In steep areas, high precipitation events are more likely to trigger mass soil movements, which can introduce large pulses of sediment to stream channels (MacDonald et al, 1991). When landslides occur at a natural rate, they provide an important supply of gravel and large trees from upslope locations to lower order stream reaches. Landslides and bank erosion are the dominant sources of sediment in unmanaged systems (Norris, et al 1999).

BACKGROUND – HISTORIC TIMBER HARVEST OVER TIME

Timber harvesting in the Little River Watershed began in earnest in the 1940's and 1950's, following the road system as it continued to be developed throughout time. Early harvesting and road building accessed the biggest trees found on gentle slopes. These early harvests were often in lower elevations on most productive ground. Harvest amounts (acres) by decade are noted in Table 17 below, and show that the greatest percentage of harvest watershed-wide occurred in the 1960’s. (Watershed Analysis 1995)

Table 17. Acres of Timber Harvest by Decade for All Land Ownerships in the Little River Watershed

Decade	**1940s acres**	**1950s acres**	**1960s acres**	**1970s acres**	**1980s acres**	**1990s acres**	**Totals**
Decade Total Acres	2,478	15,647	23,102	13,787	13,770	3,583	72,368
Percent of Watershed	1.8%	12.0%	17.5%	10.5%	10.4%	2.7%	54.88%

Stream flow and sediment delivery are affected by the timing and intensity of rainfall delivery to streams. Yearly amounts of precipitation vary greatly over the basin, ranging on average from 40 inches per year in the western edge of the Lower Little River Vicinity to 85 inches per year in both Cavitt Creek and Upper Little River Vicinities.

Sediment may be produced upslope of streams but may not be delivered until a large storm event. High peak stream flows cause bank failure (mass wasting as a result of undercutting adjacent slope), entrenchment, and bed scour (Watershed Analysis 1995).

The 1995 Watershed Analysis notes that there were a total of five peak flow events with a recurrence interval equal to or greater than a five-year flood affecting the Little River Watershed during the 1947-1966 period. Prior to that the USGS gage at Peel was not operational, so peak flow data is not available. From 1966 to 1988, only three events of similar magnitude were noted. The gage has been out of service since 1988. These intense events coincided with some of the most extensive timber harvest in the watershed that compounded the potential delivery of sediment to streams from areas not fully recovered by vegetation to reduce peak flow events.

The Watershed Analysis also notes, based on aerial photo interpretation, that a majority of the natural and management related landslides occurred during this time period (1947-1966).

SURFACE EROSION

Timber removal due to harvest can accelerate surface erosion and increase sediment delivery to streams. Accelerated sediment production and delivery occurs when bare soil is exposed to heavy rainfall and the runoff reaches streams. Generally, the accelerated surface erosion dissipates when vegetative cover is established. Only slight suspended sediment increases (excluding landslides) were found for two years following clearcut harvest in a western Oregon Cascades watershed (Reiter and Beschta 1985). In addition, ground-based harvest methods can compact soils. This reduces the soil's ability to absorb water (Watershed Analysis 1995) and can lead to more overland flow of water.

An analysis of surface erosion from harvest was completed using the Coos Bay sediment model. This model uses a soil loss equation, slope, vegetation age, and rainfall to provide an estimate of upland surface erosion. Table 18 depicts the results of this analysis.

Table 18. Estimated Soil Erosion from Uplands in Little River			
Subwatershed	Soil Erosion		
	Total (tons/year)	Erosion Rate (tons/acre /year)	% Landslide Complex Area in Subwatershed
Black Creek	18,405	1.91	40
Clover Creek	37,411	5.06	0
Cultus Creek	3,422	0.44	18
Emile Creek	26,420	3.03	6
Little River Canyon	9,698	1.26	25
Lower Cavitt Creek	63,931	7.08	46
Middle Cavitt Creek	13,321	0.94	47
Middle Little River	14,452	1.11	46
Red Butte	43,480	4.02	44
Upper Cavitt Creek	3,049	0.45	48
Upper Little River	16,116	2.14	18
Watson Mountain	825,827*	37.98	0
Wolf Creek	28,403	3.77	46
Total	*1,103,935*		

*The high amount of erosion in Watson Mountain may be due to a large amount of non-forested land.

While the model shows potential sediment production via surface erosion, it does not depict sediment delivery to streams. Studies have shown that non-channelized (surface) transport of sediment decreases as slope decreases and the number of obstructions increase within a filter strip. Vegetative buffer strips on the order of 200 feet are generally effective in controlling sediment that is not channelized (Belt, et al 1992, FEMAT 1993). The Northwest Forest Plan provides valuable riparian vegetative filters for capturing and holding sediment from hill slope surface erosion.

The buffers required by the Oregon Forest Practices Act on private forest land in Oregon are not as extensive as those required by the Northwest Forest Plan, and thus may be less effective at capturing and holding hill slope sediment. The effectiveness of Oregon's Forest Practices rules is currently under study by the Oregon Department of Forestry (ODF), and the results may provide a better indication of buffer effectiveness on private forest land. Similarly, while the Agricultural Water Quality Management Area Plan for the Umpqua Basin (Appendix D) contains provisions regarding riparian areas, there is as yet no experience in how effective this plan may be in controlling erosion.

MASS WASTING

Landslides can be triggered by timber harvest due to a loss of tree root strength and increased soil saturation from reduced tree canopy. Studies in Oregon and Washington generally indicate that the harvesting of trees increases the rate of mass failures by 2 to 4 times over that experienced on uncut areas (Reiter and Beschta 1995, Norris et al. 1999). A landslide study by the (ODF in the Coast Range following the major storms of 1995-1996 found that the general pattern is that the rate of land sliding was highest in stands 0-9 years post harvest, and lowest in stands 10 to 100 years. They further determined that landslides rates are tied to landform and slope steepness. They found that 100% of landslides occurred on slopes > 40%, 92% of landslides occurred on slopes over 60%, and concave slopes had the greatest incidence of landslides. One-third to one-half of all landslides in the Oregon Coast Range originated in headwall areas (ODF 1998). The SINMAP model (Pack, Tarboton, and Goodwin 1998) was used to create a slope stability index map. The model uses slope and a topographic wetness index to predict slope stability. The model showed that generally, the most unstable areas are steep inner gorges (over 45% slope) and headwalls.

The Watershed Analysis and a study by Stillwater Sciences (2000) in the lower portion of the North Umpqua River indicates that the number of landslides has dramatically increased with the beginning of harvesting activities in the Little River Watershed. Future clearcut and/or ground-based harvest should be avoided in steep inner gorge, unstable, or streamside areas unless a detailed geological assessment is performed which shows there is no potential for increased sediment delivery to streams as a result.

Further analysis by Stillwater Sciences (2000) indicates that following the large increase in the number of landslides before 1966, landslide numbers and sediment delivery to stream channels have shown declining trends. The sediment production and delivery rates were based on landslide inventories by USFS and the BLM. **Table 19** below shows this trend:

Table 19. Landslide Numbers and Sediment Delivery, Little River, 1947 - 1991

	Photo Period	Interval (Years)	Average frequency of all landslides (landslides/mi^{2}/yr)	Sediment Production (tons/mi^2/yr)	Sediment delivery to channels (tons/mi^2/yr)
	Pre-1946	20	0.029	245	125
	1947-1966	20	0.202	1767	1226
	1967-1982	16	0.063	542	400
	1983-1991	8	0.051	456	314
Average	1947-1991	44	0.125	1083	770

PEAK FLOWS AND BANK EROSION

Lack of forest canopy can increase rain-on-snow event peak flows leading to increased fluvial erosion. Harvest, particularly in riparian areas, also affects the amount and size of woody debris that reaches streams. Woody debris increases stream habitat complexity and serves as a storage mechanism for sediment. Beneficial sediment (gravel and cobble) serves as fish spawning habitat.

The large channel-forming runoff events in the Little River Watershed occur during the winter during rain-on-snow events. A common conclusion of the research on this type of runoff event has been that statistically significant increases in peak flow are associated with canopy removal and roads in smaller drainages (Jones and Grant, 1996; Thomas and Megahan, 1998; Jones, 2000). The loss of canopy influences snow accumulation and melt rates. Hydrologic recovery of the canopy occurs as vegetation is re-established and may require up to 40 years for full recovery (Harr and Coffin 1992). Hydrologic recovery has been described as including a canopy closure of 70% with an average tree diameter of 8 inches (Christner, 1982). In the absence of a recovered canopy, water input to soils is greater from increased snow accumulation and melt rate. Higher amounts of water input for the same climatic event shifts the frequency of occurrence of water input to a shorter recurrence interval. This can influence stream flows and bank erosion (Harr 1981, Harr and Coffin 1992).

Table 20 below from the Watershed Analysis depicts the past and current status of the various vicinities' hydrologic recoveries.

Table 20. Hydrologically Recovered Acreage in the Transient Snow Zone within the Seven Vicinities of Little River, 1995 and Past

Vicinity	Acres within transient snow zone	% of vicinity in transient snow zone	% of snow zone hydrologically recovered, 1995	% of snow zone hydrologically recovered, late 1800s - late 1930s
Lower Little River	3,625	16	58	87 - 99
Cavitt Creek	26,568	70	74	78 - 97
Middle Little	12,913	60	77	92 - 98
Wolf Plateau	12,548	86	71	85 - 99
Emile Creek	7,957	91	79	76 - 94
Black/Clover	16,729	98	80	75 - 97
Upper Little River	10,279	99	93	86 - 93

As less total federal acreage is managed in the future under the Northwest Forest Plan, hydrologic conditions in forest stands will improve in the upper areas of the watershed where federal ownership is blocked-up and mostly contiguous. The influence of canopy on rain-on-snow events will generally diminish over time. Elsewhere in the watershed, where federal lands do not occupy most of a natural drainage, the trend is not known.

A qualitative peak flow approach was adapted from the Augusta Creek Study on the Willamette National Forest to address potential bank erosion (Cissel et al., 1998). The potential susceptibility to rain-on-snow peak flows was evaluated across the watershed by assessing likely snow accumulation and melt along with the storage of ground water. Snow accumulation is a function of elevation and is grouped into elevation zones. Snowmelt is grouped by aspect with the highest melt rates for south- and west-facing slopes. Soil depth was used to assess ground water storage and was interpreted from soil inventory data. Elevation zones, aspects, and soil depths were merged into a single GIS map to identify areas of high, moderate and low susceptibility to peak flows from rain-on-snow events. **Figure 16** shows this potential susceptibility for the Little River Watershed.

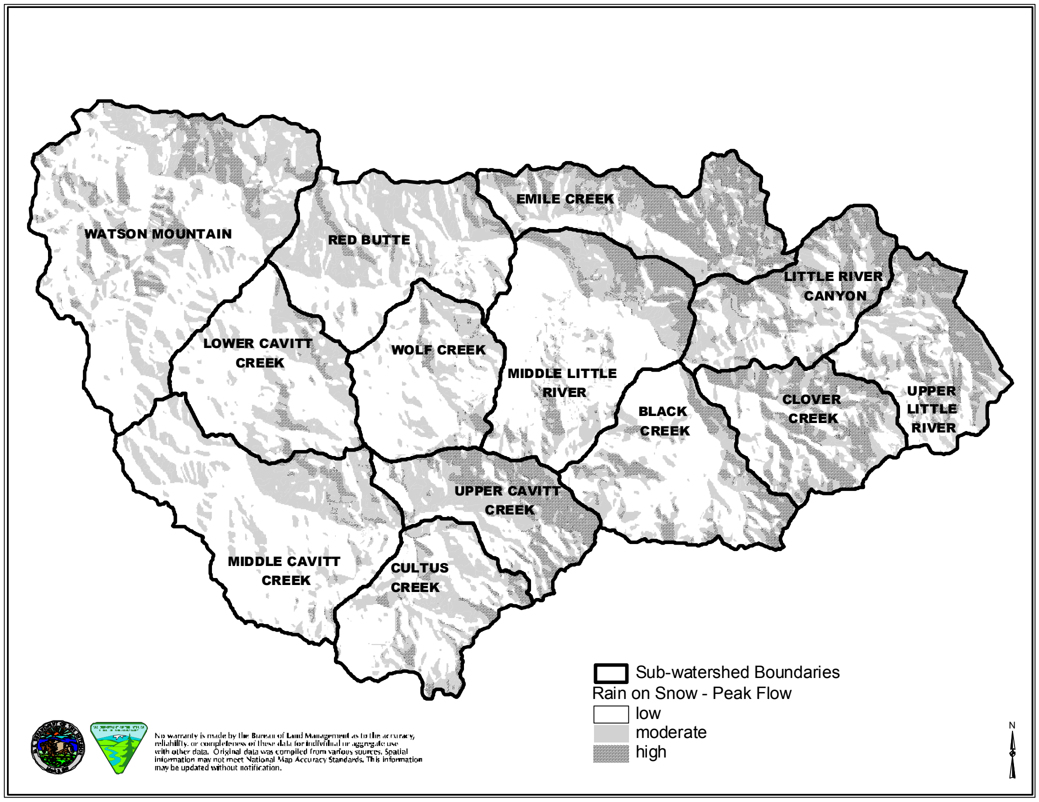

Figure 16. Potential Susceptibility to Rain-on-Snow Peak Flow Events in Little River.

The higher risk runoff areas in the Little River Watershed were then combined with GIS information showing forest stands that are not hydrologically recovered (stands less than 40 years old). The results identified those areas that have a higher risk of naturally augmented rain-on-snow runoff and that are likely hydrologically unrecovered. The deep, finer textured soils of the landslide-earthflow complex are highly susceptible to stream down-cutting and bank erosion. Areas of high susceptibility to rain-on-snow peak flows and low hydrologic recovery that are upslope and contribute to streams in landslide-earthflow terrain would potentially have the greatest influence on bank erosion.

Figure 17 provides an indication of places where additional harvest and associated roads would have the most impact on bank erosion. This graphic represents current conditions only. As both management and recovery occur, this information will change. Currently most of the potential high peak flow and low hydrologic recovery areas are on federally managed lands indicated on **Figure 17**.

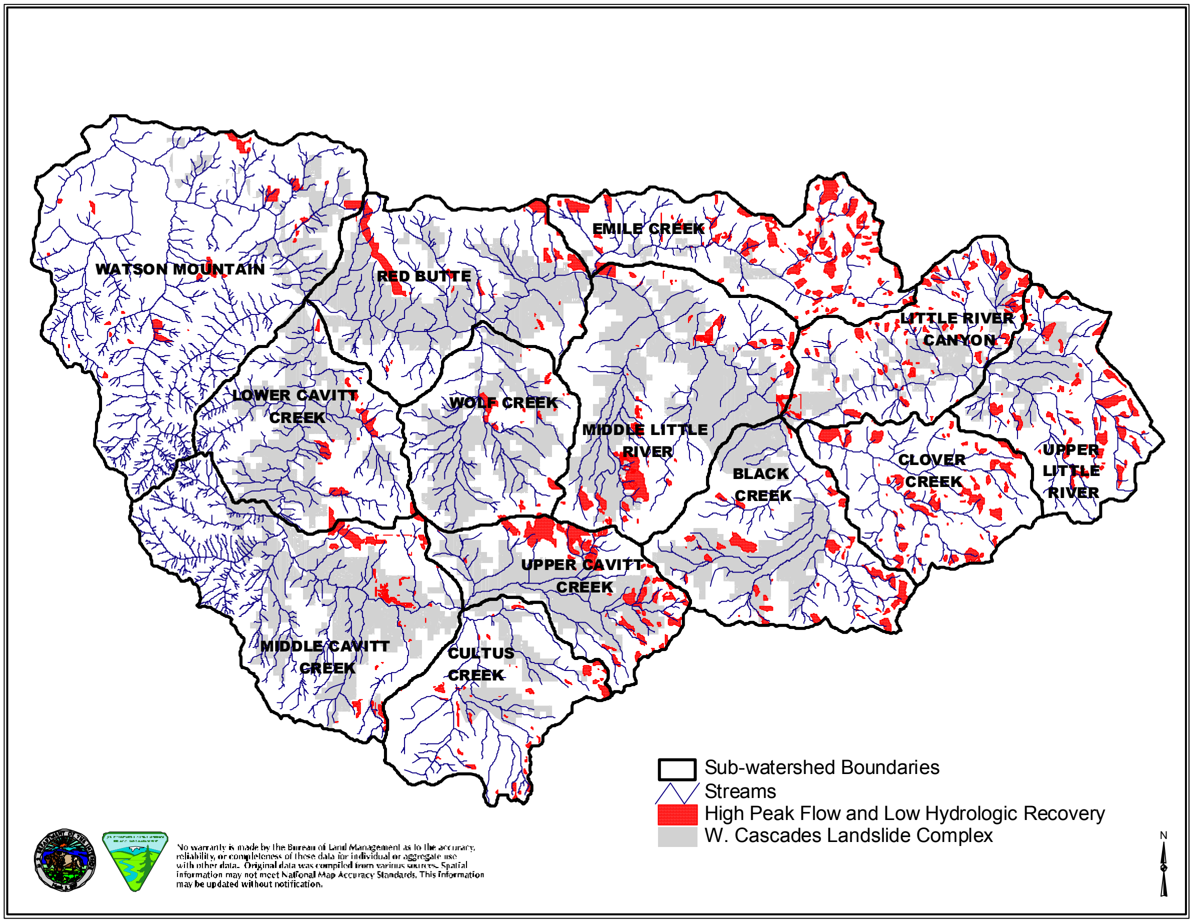

Figure 17. Areas of High Peak Flow and Low Hydrologic Recovery in Little River

ROADS

The road transportation network is an important influence on sediment production and delivery. In addition to the effects of land types, road density/use/design/location can be important in affecting the extent and magnitude of road-related sediment impacts (Reiter et al. 1995). King and Tennyson (1984) observed altered hydrology when roads constituted more than 4% of the drainage area. This correlates to approximately 4 miles per square mile of drainage area. Other studies evaluating storm response to road construction range up to 15% of the area in roads. Results are extremely variable because the effects of roads are not well defined and are difficult to detect, especially as the size of flood increases (Grant, Megahan, and Thomas 1999).

Road densities in the Little River Watershed are relatively high and fairly evenly distributed (**Table 21** below, from WQRP, Appendix C, Figure 24). There are 954 miles of roads distributed over 206 square miles for an average density of 4.6 Mi/Mi2. A total of 630 miles are under government jurisdiction, including 27 miles managed and maintained by Douglas County. Road densities in the high-risk geomorphic land types are 5.1 in Landslide-Earthflow, 4.5 in Klamath Granitics, and 4.3 in Western Cascades Volcanics (Watershed Analysis, 1995).

Table 21. Road Densities (For All Roads in the Little River Watershed)

Subwatershed	Road Density (mi/mi²)	Subwatershed	Road Density (mi/mi²)
Black Creek	4.9	Middle Little River	4.9
Clover Creek	3.7	Red Butte	4.4
Cultus Creek	4.5	Upper Cavitt Creek	5.0
Emile Creek	4.0	Upper Little River	4.4
Little River Canyon	4.3	Watson Mtn	4.7
Lower Cavitt Creek	4.8	Wolf Creek	4.5
Middle Cavitt Creek	5.3		

Native road surfaces, road cuts and fill slopes, and ditches represent potentially exposed surfaces subject to surface erosion and mass wasting. Subsurface flow may be partially intercepted along road cuts and transferred into more rapid runoff via ditches, causing increased peak flows and mass wasting. Failed road/stream crossings and stream channel diversion pose a risk for severe sedimentation and mass wasting.

Road surface erosion was estimated using SEDMODL and results indicate an average of 4.2 tons/mi²/yr.

DITCHES

Ditch lines along roads collect water that is drained from the road surface and cut slopes. When ditches flow into streams (effectively serving as an extension of the stream network), water is delivered more quickly than in roadless situations, thereby accelerating peak flows. Table 22 (from the 1995 Watershed Analysis) depicts the extent of stream network extension and potential peakflow increases.

Table 22. Estimated Stream Network Extension and Possible Peakflow Increases in the Seven Vicinities of Little River

VICINITY	MILES OF NATURAL STREAMS	MILES OF ROAD FUNCTIONING AS STREAMS	STREAM NETWORK EXTENSION (%)	ESTIMATED RANGE OF FLOW INCREASES AS A RESULT OF STREAM EXTENSION (%)
LOWER LITTLE RIVER	146.4	35.2	24	27-57
CAVITT CREEK	258.1	73.6	24	27-65
MIDDLE LITTLE RIVER	120.3	41.3	34	40-80
WOLF PLATEAU	80.3	28.3	35	41-83
EMILE CREEK	42.5	14.4	34	39-79
BLACK/CLOVER	91.8	29.6	32	37-75
UPPER LITTLE RIVER	62	17.9	29	33-66

Roads can act to concentrate run-off and divert natural flow patterns, potentially causing mass wasting. Data collected for a 1995 road/stream-crossing inventory of federally managed roads in Little River shows that the average ditch length at stream crossings is 337 feet. Ditch length is the distance of ditch line that flows water into a stream. It is measured from the point it spills into a stream to the nearest culvert or cross drain. Table 23 shows the number and length of ditches at stream crossings for federally managed roads in the Little River.

The key to reducing the effects of ditches on sediment delivery is to reduce the length of the road drainage ditch that leads directly to the point where it discharges into the channel (Norris et al. 1999). Restoration would involve installing cross drains to shorten ditch lengths and disperse water away from the point it enters a stream.

Table 23. Number and Length of Road Ditches for Federally Managed Roads in Little River Watershed

	Number of Ditches			
	< 300’	=> 300’ & < 600’	=> 600’ & < 900’	=> 900’
Totals	603	233	108	100

The longer the ditch, the more potentially detrimental to natural infiltration rates.

STREAM CROSSINGS

Stream crossings are the places where roads intersect streams. A drainage structure is normally installed to allow vehicle passage. In most cases, this structure consists of a culvert with soil and rock around it. Culverts can constrict the natural flow of water and restrict the normal transport of sediment and debris. When culverts become plugged and dam water, they can cause fills to become saturated, leading to failure. Plugged culverts can cause water to rise up into the road prism and spill into ditches where it is diverted to another stream. The road/stream-crossing inventory for federally managed roads in the Little River was re-evaluated for this analysis to determine water diversion potential and the risk and consequence of stream crossing failure (Table 24). Road/stream crossings were rated from 1 (low) to 5 (high) based on the risk of failure and the consequence (sediment delivery) of the failure.

Water diversion potential is the likelihood high water will be diverted down a ditch into another stream. Restoration of stream crossings would eliminate water diversion potential and reduce the risk of failure. It includes redesigning, installing, or maintaining drainage structures and stabilizing road fills around drainage structure. All culverts should be sized to pass a 100-year flood and associated sediment and debris. Some of the information collected for the 1995 inventory was based on a subjective evaluation of conditions. A thorough site analysis will be needed during project level planning to verify the need for restoration.

Table 24. Road/Stream Crossings Risk and Consequence of Failure and Water Diversion Potential for Federally Managed Roads in the Little River Watershed

Subwatershed	Risk and Consequence of Failure (Number of Crossings by Risk Class)					Water Diversion Potential (Number of Crossings)	
	1	2	3	4	5	Yes	No
Black Creek	2	5	44	12	9	45	38
Clover Creek	8	7	15	5	3	20	25
Cultus Creek	8	17	24	9	4	28	39
Emile Creek	14	25	38	5	2	50	44
Little River Canyon	11	14	55	19	8	81	29
Lower Cavitt Creek	1	3	40	5	3	35	20
Middle Cavitt Creek	5	7	23	8	5	34	18
Middle Little River	7	21	57	34	8	78	58
Red Butte	10	15	35	8	1	48	23
Upper Cavitt Creek	8	21	43	13	6	61	37
Upper Little River	6	16	33	20	8	41	53
Watson Mountain	7	10	24	5	4	39	22
Wolf Creek	4	12	46	13	7	53	29
Totals	**91**	**173**	**477**	**156**	**68**	**613**	**435**

Those in Risk Class 5 have the highest risk of failure and the highest consequence of failure (only stream crossings with a culvert were given a rating). As an example, Black Creek has 2 crossings in Risk Class 1, 5 crossings in Risk Class 2, and so forth. A total of 68 crossings were determined to be in Risk Class 5.

ROAD PRISM

Roads have the greatest potential for hydrologic effects where they parallel streams, particularly where road fills have been placed in the floodplain (BLM 2000). In valley bottoms, roads can affect stream morphology by hardening stream banks and constricting streams during high flows. On hill slopes, road fills and cut slopes that become saturated with water can fail and deliver sediment to streams. Surface erosion from inadequate (native) surfaces, rutting, and lack of cross drains is more likely to be delivered to streams when a road is close to a stream and there is little vegetative buffer.

Analysis of sediment delivery due to surface erosion from federally managed roads was accomplished using SEDMODL. The model considers roads that are within 200 feet of a stream and generally identifies more delivering road segments than actually exist on the ground. The model uses elevation, road data[2], road cut slope condition, stream location, precipitation, geology, and soils information. **Table 25** shows the estimated surface erosion delivery in each subwatershed along with the miles of road segments rated as medium or high sediment

[2] SEDMODL is designed to run with road locations only or with the additional attribute information of surface/use/width. Runs of the model with attribute information on actual road conditions provide more reliable model results and can be used to examine the relative relationships between different values of sediment delivery or as a good indicator of actual sediment inputs. This information is available for federally managed roads in the Little River Watershed and was used in the model. Stream location data that was used is the best that is currently available, however, there may be more ephemeral streams on the ground than are represented in GIS.

deliverers in landslide-earthflow complex. Those segments rated as medium or high deliverers that fall within landslide-earthflow complex areas are most likely to accelerate detrimental (fine) sediment delivery to streams. The Watershed Analysis found that the Cavitt Creek and Wolf Creek/Middle Little River areas are the areas of highest priority for transportation assessment and planning efforts.

According to Luce and Black (1999), road-related surface erosion appears to be concentrated in the first few years after construction. Landslide-related erosion could occur many years later, and is highly episodic. Wemple et al. (1999) found that fill slope slides were the dominant process of sediment production from roads. An analysis of several miles of road in the Watson Mountain subwatershed showed that sediment production from road cut and fill slope mass wasting was 12 –16 times that of surface erosion. The Watershed Analysis found that, in general, roads located on slopes in excess of 60% slope and within 200 feet of streams have the greatest potential to deliver landslide-generated sediment to streams.

All roads should have surface and drainage facilities or structures that are appropriate to their patterns and intensity of use. A study of roads in western Oregon found that variability in sediment production from road segment to road segment is high. Most segments produce little sediment, while only a few produce a great deal. It is possible to substantially reduce road erosion by targeting those sections with the greatest sediment production (Luce and Black 1999). Restoration efforts would include road treatments (installing drain dips, adding road surfacing material, repairing ruts, stabilizing road cuts and fills on slopes >60%) and road decommissioning. The SEDMODL provides an indication of relative road surface erosion and likely problem areas that will require a more detailed review to verify the need for restoration. Future roads should not be located in steep inner gorge or unstable headwall areas except where alternatives are unavailable (Redwood Creek TMDL 1998).

Table 25. Estimated Surface Sediment Delivery from Federally Managed Roads in the Little River Watershed

Subwatershed	Total Erosion (tons/year)	Average Erosion Rate (tons/mi2 /year)	Miles of Medium/High Sediment Delivering Segments in Landslide Complex Areas
Black Creek	51	3.4	6.4
Clover Creek	23	2.0	0.0
Cultus Creek	51	4.2	1.7
Emile Creek	23	1.7	0.4
Little River Canyon	82	6.8	3.8
Lower Cavitt Creek	83	5.9	4.6
Middle Cavitt Creek	69	3.1	2.7
Middle Little River	43	2.1	4.2
Red Butte	93	5.5	3.7
Upper Cavitt Creek	86	8.1	5.2
Upper Little River	54	4.6	1.9
Watson Mountain	100	2.9	0.7
Wolf Creek	53	4.5	4.2
Totals	**811**	**4.2**	**39.5**

Model uses road attributes showing a breakdown of road surface and use. If model is run without this attribute information (instead using the defaults of gravel surface and light use), the total amount of sediment is 346 tons.

6.4 RIPARIAN CONDITIONS

The condition of riparian areas varies widely across the basin. In general, riparian areas located in downstream areas within the Little River and mainstem Cavitt Creek have undergone the largest change from what are believed to be natural, reference conditions (evident from past aerial photos). The majority of the riparian areas can be characterized as having narrow bands of small hardwood and conifer species. Where buffer strips have been left, they have been narrow with the larger trees having been selectively removed. These altered riparian areas are not currently sources of large wood that could enter the stream, and they do not provide the cooler, moist microclimate characteristic of many healthy, functioning riparian ecosystems. (Watershed Analysis 1995)

Based on interpretation of historic stand conditions from aerial photos, 72 to 88 percent of the riparian areas within 360 feet of fish bearing streams in the basin was in a late seral condition with large conifers and large hardwoods dominating the stands. Today, however, roughly 30 percent of riparian stands along fish bearing streams in the watershed have these characteristics. Roads are also present in riparian areas with a long-term loss of vegetation. These conditions vary by vicinity in Little River. See Table 26 below for a summary of past and present riparian conditions on fish-bearing streams.

Table 26. Condition of Riparian Forests Within 360 Feet on Either Side of Fish-Bearing Streams, Little River Watershed, Past and Present

Vicinity	Miles of fish-bearing stream	% of Riparian in late seral (Reference range--late 1800's to late 1930's)	% of Riparian in late seral (1995)	Miles of road located within 360 feet of fish-bearing streams
Lower Little R.	22.4	81-86 %	7 %	21.9
Cavitt	33.5	78-87 %	24 %	21.0
Middle Little R.	21.7	72-88 %	32 %	5.5
Wolf Plateau	4.7	79-86 %	23 %	1.5
Emile	11.2	58-81	49	5.5
Black Clover	13.1	64-80	47	8.7

Table 26. Condition of Riparian Forests Within 360 Feet on Either Side of Fish-Bearing Streams, Little River Watershed, Past and Present				
Vicinity	**Miles of fish-bearing stream**	**% of Riparian in late seral (Reference range--late 1800's to late 1930's)**	**% of Riparian in late seral (1995)**	**Miles of road located within 360 feet of fish-bearing streams**
Upper Little R.	13.0	80-85	59	5.2

6.5 LARGE WOODY DEBRIS AND SEDIMENT STORAGE

Large woody debris is an important mechanism for the storage and slow release of sediment over time. Wood is delivered via chronic and episodic events to first- and second-order streams where it traps sediment. The buildup of wood and sediment continues until it is delivered downstream, through mass movement of the material (debris torrent) during large stream flow events. The material is then incorporated into the channel structure of larger streams, where it becomes part of normal stream function (Norris et al. 1999). This includes capture and storage of beneficial gravel and cobble for fish spawning and aquatic insect production. Trees that fall into streams usually come from 30 meters (98 feet) of the channel edge; 70 to 90 percent of the large wood in streams is derived from this distance (Norris et al. 1999). The total amount of wood in the streams may not change with timber harvest, but the size of the wood is reduced (Norris et al. 1999). **Table 27** shows the percentage of total riparian area (using Northwest Forest Plan riparian reserve widths) that has been harvested since 1946.

Protection of streamside zones by leaving vegetation intact will help maintain the integrity of channels and preserve important terrestrial-aquatic interactions (Hicks et al 1991). The Northwest Forest Plan Standards and Guidelines provide for riparian reserves along streams. These reserves will provide a future source of large woody debris for streams. In addition, re-introducing fire into the ecosystem could provide a source of wood for streams, as fire creates snags that can then fall into the stream.

Table 27. Percent of Total Riparian Area that has been Harvested Since 1946

Subwatershed	% Harvest in Riparian Areas	Subwatershed	% Harvest in Riparian Areas
Black Creek	42	**Middle Little River**	62
Clover Creek	22	**Red Butte**	57
Cultus Creek	26	**Upper Cavitt Creek**	42
Emile Creek	43	**Upper Little River**	28
Little River Canyon	32	**Watson Mtn**	52
Lower Cavitt Creek	69	**Wolf Creek**	66
Middle Cavitt Creek	88		

Prior to 1946, less than 2% of the watershed had been roaded and harvested (Watershed Analysis 1995). Riparian areas were calculated by applying Northwest Forest Plan riparian reserve widths to all lands.

6.6 SEDIMENT BUDGETS

Sediment is a natural part of stream systems, and healthy stream systems maintain an equilibrium between sediment input, routing, and in-stream storage of sediment. This means maintaining a balance between the amount of fine sediment, coarse bed load sediment and larger elements of in-stream structure (wood, boulders).

Management activities have affected this natural equilibrium by increasing sediment inputs and decreasing in-stream storage. A sediment budget provides a framework for categorizing sources of sediment and analyzing the effects of land use on sediment production and routing.

A sediment budget is a quantitative statement of the process and rates of mobilization, production and discharge of sediment in a watershed (Dietrich et al. 1982). A complete sediment budget incorporates sediment input (I), change in the volume of stored sediment (Δ S) and sediment output (O) (i.e., sediment yield out of a watershed) components. The general sediment budget equation is a continuity equation:

Sediment Input (I) + Change in Volume of Sediment Stored (ΔS) = Sediment Output (O)

Net change in sediment storage links sediment inputs and outputs and may be manifested by changes in channel morphology. (Stillwater 2000). Change in sediment storage, however, is the most poorly understood component of the sediment system (e.g., Swanson et al. 1982, Dietrich et al. 1982).

Landslides, soil creep, and surface erosion contribute varying degrees to the overall inputs. The increases in human caused contributions to the sediment budget and in some cases exceedances in the beneficial uses of these receiving waters as noted earlier creates the need to determine the amounts of these inputs above background conditions. Most of the following information was contained in the Stillwater SciencesNorth Umpqua Cooperative Watershed Analysis (2000) Technical Appendix to the Synthesis Report, Appendix 2-1: Sediment Budget for the North Umpqua River Basin. Data from that report for the lower reach of the North Umpqua River (Stillwater Sciences 2000) provides an estimate of sediment loading.

Table 28 provides the sediment budget developed by Stillwater Sciences for the Lower Basin of the North Umpqua, which includes Steamboat Creek. The techniques used to estimate landslide delivery and amounts to the stream network included aerial photograph mapping of landslides, and estimating volumes and densities based on regional values. It is noted that these landslide volumes were large compared to sizes reported elsewhere in Oregon; this was thought to compensate for smaller omitted landslides. No data are available on sediment delivery ratios (i.e., the amount of sediment mobilized on hillslopes that is delivered to channels) in the North Umpqua subbasin. Based on discussions with Umpqua National Forest geologists and their observation that management landslides tend to have higher delivery ratios than natural landslides, Stillwater Sciences assumed a 50% sediment delivery ratio for natural landslides and a 75% delivery ratio for management landslides (Stillwater Sciences 2000). Stillwater suggested an uncertainty range of about 50%, which is reflected in Table 28 below.

Table 28. Sediment Budget for Lower North Umpqua River (Data from Stillwater Sciences 2000)

Sediment Budget LOWER BASIN	Reference Condition (tons/mi.^{2}/yr)	Current Condition (tons/mi.^{2}/yr)
Input		
Landslides	171 ± 85	798 ± 400
Soil Creep	71 ± 35	71 ± 71
Surface Erosion	14 ± 7	Unknown
Total Inputs	256 ± 128	869 ± 435 landslides and creep
Output	285 ± 143	1339 ± 700
Storage Change	assumed 0	57±29 (due to LWD removal only)

Uncertainty regarding this sediment budget results from a lack of data on the storage component, surface erosion, and deficiencies in the methodology of the landslide inventory used in the Little River Watershed analysis. USFS and BLM sought to better define the Stillwater Sciences sediment budget inputs for the Little River Watershed by embarking on a landslide study of two drainages (6TH field subwatersheds can be further divided into 7th field drainages) using field verification and inventorying the various landslide components as they related to channel delivery in the two drainages. This information was used to extrapolate sediment budget values on a watershed scale.

Tuttle Creek represents a relatively unmanaged (or reference) setting and Engles Creek represents a managed setting. Although the area of analysis was significantly smaller than the Stillwater Sciences North Umpqua study area (2.2 mi^2 vs. 558.7 mi^2), results indicate that the average landslide area, volume, and mass as well as sediment delivery rates are significantly less.

Sediment storage and subsequent release by large wood removal may account for 20% of the increase in sedimentation rates above pre-management conditions (28.5 to 68.4 tons/mi^2/yr) over a long-term period (Stillwater Sciences 2000). The Tuttle and Engles study inventoried the current distribution of large wood (LW) using the Forest Service Pacific Northwest Region protocol (2000). The associated figure for sediment stored was an ocular estimate that placed sediment volume into one of five categories. Tuttle Creek was identified as a “least disturbed” system with minimum riparian or large wood impacts from management activities. Engles Creek reflects management activities from the pre-stream cleanout and stream cleanout periods. Results of the study for Tuttle and Engles Creek are displayed in Table 29 along with findings of Stillwater Sciences.

Table 29. Large Wood and sediment storage for Lower North Umpqua, Tuttle, and Engles Creek Watersheds

Drainage Storage and Sediment Parameters	Lower North Umpqua (Stillwater Sciences)	Tuttle Creek	Engles Creek
Stream order	3rd – 5th	3rd	3rd
Stream length (mile)	389	2.4	1.2
Average channel width (feet)	26	16	17
Number of channel widths between LW sites (distance)	5 (130 feet)	3 (48 feet)	7 (119 feet)
Number of LW storage sites per mile[a]	41	110	44
Average sediment volume per active storage site[b] (cubic feet)	1,059	1,012	338
Average sediment storage per length (cubic feet per foot)	8	21	3

[a] Large Wood storage sites occurring each mile: [(5280 ft/mi)/(ave. channel width)]/(number channel widths between LW sites)
[b] Not all storage sites inventoried had stored sediment; only those sites with stored sediment are included.

This study indicates that large wood storage sites occur twice as frequently in the selected "least disturbed" Tuttle Creek setting compared to Engles Creek. Stillwater Sciences estimated even less frequent occurrence of large wood (every 130 feet). The average sediment storage forced by large wood was also found to be different for Tuttle and Engles creeks. The average volume of sediment stored per length of channel in Tuttle Creek was 7 times greater than Engles Creek and about 2.5 times greater than Stillwater Sciences' estimate. Although Stillwater Sciences estimated a nearly similar volume of sediment per active storage site as found in Tuttle Creek, there were fewer active sites identified (41 sites/mile compared to 110 sites/mile).

Assuming that other managed lands in the Little River Watershed are similar to Engles Creek, the channels in these managed areas are storing only a third of the potential sediment at existing large wood sites in comparison to a less managed area, such as Tuttle Creek, and at only about half the number of storage sites. In the long term, the key to improving in-channel sediment storage is the growth of riparian trees. Where past management activities have replaced old growth riparian with younger stands, recruitment of large stable wood awaits maturation (greater than 60 years [Grette 1985; Bilby and Wasserman 1989]). In the meantime, the legacy large wood in streams continues to decay and the associated storage of sediment declines (MacDonald 1991).

Under current conditions in the Stillwater Sciences sediment budget, an output rate of 1339 ± 700 tons/mi²/yr was calculated from stream gauge flows and turbidity measurements for Steamboat Creek from 1957-1996. Steamboat Creek is similar geomorphically to Little River, although it appears to route flow more efficiently during flood events (USFS open file report 93-63 1993). Steamboat Creek's current sediment output is approximately 4 times that of the reference condition.

Table 30 provides a comparison of Stillwater Sciences' sediment budget for the Lower subbasin reach of the North Umpqua River and a sediment budget based on the landslide study in the Tuttle and Engles Creek drainages. Due to limited field verification, considerable uncertainty is associated with the figures from the Stillwater Sciences sediment budget projections. A rough estimate of the error range is ±50% (Stillwater Sciences 2000).

Table 30. Sediment Budgets for Lower North Umpqua and Engles and Tuttle Drainages

	Lower North Umpqua (Stillwater Sciences)		Engles and Tuttle Creek Landslide Study	
Sediment Budget	Reference Condition (tons/mi.^{2}/yr)	Current Condition (tons/mi.^{2}/yr)	Reference Condition (Tuttle) (tons/mi.^{2}/yr)	Current Condition (Engles) (tons/mi.^{2}/yr)
Input				
Landslides [a]	171[b]	798[b]	48[c]	430[d]
Soil Creep[e]	71	71	71[f]	71[f]
Surface Erosion	14[g]	Unknown	14 [g]	18[h]
Total Inputs	256	869	133	519
Output	285[g]	1339[i]	Unknown	Unknown
Storage Change	0[j]	(57)	0[j]	Unknown[k]

[a] Landslide sediment inputs include rapid-shallow slope failures (including debris flows) that originate in colluvial hollows, as well as from slumps, and active toe zones of earth flows.
[b] This value is the average of sediment delivery rates based on landslide inventories in the Upper Steamboat basins and the Little River AMA Watershed Analysis (using 1946 photos).
[c] Current condition in Tuttle Creek, a reference drainage in Little River (with a small landslide dataset of recent features and assumption of 25 year frequency).
[d] Current conditions in Engles Creek (~2-3 mi²), a managed drainage in Little River, is based on a small landslide dataset and the assumption of a 3-year frequency of landslides observed. The landslide data is dominated by a debris flow feature initiated by road drainage in a recent clearcut. The frequency of the coincident events of storm flows and the harvest/road drainage features observed in Engles Creek is unknown.
[e] Sediment inputs from creep are assumed to be the same for reference and current conditions.
[f] Soil creep was not analyzed, these numbers are from the Lower North Umpqua sediment budget (Stillwater Sciences 2000).
[g] From studies conducted by Swanson et al (1982) in the H.J. Andrews Experimental Forest, Oregon (Western Cascades lithography).
[h] Road surface erosion was estimated using SEDMODL and results indicate approximately 4.2 tons/mi²/yr.
[I] (McBain and Trush 1998).
[j] Based on an assumption of long term equilibrium between inputs and outputs (i.e.,no long-term net aggradation of degradation).
[k] See figure 22 for comparison of sediment storage for Tuttle and Engles Creek by stream length (ft^2/ft).

The inequalities in the sediment budget implied by these figures (inputs plus storage changes do not equal output) probably result from a lack of understanding of the storage component and deficiencies in the methodology of the landslide inventory used in the Little River Watershed Analysis. A particular deficiency is in the quantity of the inner gorge landslides that are overlooked by an aerial photo inventory.

The sediment budget is indicative of general patterns of geomorphic processes and provide rough estimates of changes in the magnitude of sediment process rates. This data indicates that current sediment inputs are up to four times that of the reference condition and are likely due to extensive and intensive management activities in the watershed. Landslides accounted for 36% of the overall sediment budget in the reference condition and 83% of the overall sediment budget in the current condition.

SUMMARY OF MANAGEMENT-RELATED SEDIMENT SOURCES

Roads, landslides, and bank erosion are believed to be the dominant sources of sediment in managed systems and there is a strong interaction with storms. Canopy indirectly affects fluvial erosion through increased peak flows. Given riparian protection, landslides and roads become the dominant sediment sources likely to be influenced by management action (Norris et al. 1999). In the Western Cascades, road fill failures were found to represent the most frequent cause of debris flow initiation (Swanson and Fredricksen 1982). In a study of landslides after a large storm event in the Cascade Range of Oregon, Wemple et al. (1999) found that road-related erosion processes were a significant part of overall sediment production in the basin during large storm events. An (ODF study of landslides and storm impacts for the storms of 1996 concluded that while the number of road-related landslides were low, the size of these landslides were about 4 times larger on average than landslides not associated with roads. The ODF study as well as the landslide study in the Tuttle Creek and Engles Creek 7th field drainages show that landslides that enter stream channels are most common in steep, inner gorge areas adjacent to streams.

How these increased sediment inputs affect long-term in-stream sediment storage and transport is not clearly understood. Historically, it is likely that individual drainages were periodically highly impacted by sedimentation (due to episodic events such as landslides). Currently, most drainages are highly impacted.

6.7 LOADING CAPACITY

In order to determine the TMDL, it is important to assess the magnitude of the instream sediment problems and the associated levels of sediment source reductions needed to address instream problems. The result of this assessment is an estimate of " loading capacity " - the amount of sediment the streams can assimilate and still meet water quality standards. This section assesses the degree to which sediment reductions are needed from sources in the Little River Watershed to alleviate the instream sediment problems discussed in the problem statement and numeric targets sections. The analysis is based on two methods of comparing existing and desired conditions for the watershed:

1. Quantitative comparison of average sediment loading rates per square mile in reference and current condition areas of Little River Watershed; and

2. Qualitative comparison of existing and available historic conditions with target levels for the

instream indicators selected in the numeric target section.

Precisely estimating the link between the amount of sediment from hillslopes (t/m^2/year) and the numeric indicators of conditions in streams (% fines in riffles, macroinvertebrate indices, LWD goals) is difficult due to the nature of sediment movement in a system with variable rainfall and variable channel structure and slope. Sediment movement is complex both spatially and temporally. Sediment found in some downstream locations can be the result of hillslope processes of decades past. Thus, there is inherent complexity in linking the routing and timing of particular habitat effects to particular increases in loadings from particular hillslopes.

Nevertheless, management activities can clearly increase sediment delivery and instream habitat can be adversely affected by increased sediment inputs. Therefore, it is reasonable to link increases in hillslope sediment to decreased stream habitat quality (South Fork Eel TMDL 1999). Because there are no reliable direct linkages to evaluate (i.e., the sediment-impact relationships tend to be separated in time and space) and no reliable methods for modeling those linkages, it is necessary to rely on these less certain inferential methods. DEQ believes that through future monitoring and evaluation, it will prove more feasible to evaluate these cause-effect linkages with certainty than was feasible for this TMDL (Redwood Creek TMDL 1998).

SUMMARY OF APPROACH

In determining the Loading Capacity for sediment, the initial step was to estimate background levels of sediment input. This was done using a background sediment budget developed for the larger North Umpqua subbasin. The next step was to estimate current levels of sediment input. Again, this was done using a current sediment budget developed for the larger subbasin.

After the background and current sediment inputs were estimated, it was necessary to determine by how much sediment inputs needed to be reduced in order to meet water quality standards. Literature values for potential reduction in management-related sediment ranged from 50 % for management-related mass wasting (landslides), to 90 % from roads. Best professional judgment was exercised in selecting 70 % as the initial value for determining whether water quality standards would be met, since the largest component of the sediment budget for the Little River is from landslides. An argument could be made for a lower value; however, 70 % incorporates a margin of safety.

By reducing the value for management related sediments by 70 %, the resulting sediment budget estimated that total sediment inputs could be reduced to approximately 406 tons per square mile per year. This value falls within the margin of error for background sediment inputs. Given the uncertainty inherent in the data, this appeared to be a reasonable value for the initial Loading Allocation for sediment.

REFERENCE AND CURRENT CONDITION LOADS

Efforts by Stillwater Sciences and the joint effort by the Umpqua National Forest and Roseburg BLM in preparing the Watershed Analysis identified reference and current sediment loading rates on a watershed scale. The FS/BLM effort through field verification estimated less sediment delivered to the stream channel. Stillwater Sciences technical report indicated an estimated reference condition of sediment delivery for the Little River Watershed of 125 t/mi^2/yr. The value noted in the Stillwater sediment budget for the Lower North Umpqua includes values for Steamboat basin, elevating the estimate of sediment delivery to the channel. A revised sediment budget using the information for the Little River Watershed is noted below. The surface erosion values estimated by UNFS/BLM are used in the Stillwater budget to allow comparison of Total Inputs. The three sediment budgets are compared below in **Table 31**:

Table 31. Sediment Budgets for Lower North Umpqua, Little River, and Engles and Tuttle Drainages

	Lower North Umpqua (Stillwater Sciences)		Little River		Engles and Tuttle Creek Landslide Study USDAFS/USDIBLM	
Sediment Budget	Reference Condition (tons/mi.^{2}/yr)	Current Condition (tons/mi.^{2}/yr	Reference Condition (tons/mi.^{2}/yr)	Current Condition (tons/mi.^{2}/yr)	Reference Condition (Tuttle) (tons/mi.^{2}/yr)	Current Condition (Engles) (tons/mi.^{2}/yr)
Input						
Landslides [a]	171[b]	798[b]	125[b]	770[b]	48[c]	430[d]
Soil Creep[e]	71	71	71	71	71[f]	71[f]
Surface Erosion	14[g]	Unknown	14[g]	18[h]	14 [g]	18[h]
Total Inputs	256	869	210	859	133	519
Output	285[g]	1339[i]	Unknown	1339[i]	Unknown	Unknown
Storage Change	0[j]	(57)	0[j]	(57)	0[j]	Unknown[k]

[a] Landslide sediment inputs include rapid-shallow slope failures (including debris flows) that originate in colluvial hollows, as well as from slumps, and active toe zones of earth flows.
[b] This value is the average of sediment delivery rates based on landslide inventories in the Upper Steamboat basins and the Little River AMA Watershed Analysis (using 1946 photos).
[c] Current condition in Tuttle Creek, a reference drainage in Little River, is based on a small landslide dataset of recent features and assumption of 25 year frequency.
[d] Current condition in Engles Creek (~2-3 mi²), a managed drainage in Little River, is based on a small landslide dataset and the assumption of a 3-year frequency of landslides observed. The landslide data are dominated by a debris flow feature initiated by road drainage in a recent clearcut. The frequency of the coincident events of storm flows and the harvest/road drainage features observed in Engles Creek is unknown.
[e] Sediment inputs from creep are assumed to be the same for reference and current conditions.
[f] Soil creep was not analyzed, these numbers are from the Lower North Umpqua sediment budget (Stillwater Sciences 2000).
[g] From studies conducted by Swanson et al. (1982) in the H.J. Andrews Experimental Forest, Oregon (Western Cascades lithography).
[h] Road surface erosion was estimated using SEDMODL and results indicate approximately 4.2 tons/mi²/yr.

[l] Based on sediment yield calculated for the Steamboat Creek basin by McBain and Trush (1998).
[j] Based on an assumption of long term equilibrium between inputs and outputs (i.e., no long-term net aggradation of degradation).
[k] See figure 22 for comparison of sediment storage for Tuttle and Engles Creek by stream length (ft^3/ft).

The specialists who developed the sediment budget in the federal WQRP have reservations about the certainty of the values for the Tuttle and Engles drainages (the two right columns of **Table 31** above). Although the Tuttle and Engles sediment budget values may more accurately depict the sediment delivery to the stream channels, the values developed by Stillwater for the Lower North Umpqua are adopted for this TMDL to provide a margin of safety (an overestimation of the quantity of sediment delivered to the stream channels).

"Controllable" sources of sediment are defined as those which are associated with human activity *and* will respond to mitigation, altered land management, or restoration. The percentages are based on an understanding of the available mitigation, land management and/or restoration measures which have been developed for a variety of situations. The percentages reflect professional judgment of how successful the various best management practices (BMPs) generally are in controlling these sources (Redwood Creek TMDL 1998). As noted in the Federal WQRP, a 70% controllable sediment value was selected based on information included in approved sediment TMDLs for Redwood Creek TMDL 1998, Garcia River Sediment TMDL 1998, both in California, and Simpson Northwest Timberlands TMDL in Washington. Sediment delivery for road surface erosion has been estimated as 70% controllable (Burroughs 1989). Literature values for potential reduction in management-related sediment ranged from 50 % for management-related mass wasting (landslides), to 90 % from roads. Best professional judgment was exercised in selecting 70 % as the initial value for determining whether water quality standards would be met, since the largest component of the sediment budget for the Little River is from landslides. According to the Watershed Analysis, management-related landslides have increased from 1.9 % of total landslides before 1946 to 84.4 % of total landslides during the years 1983-1991.

CONTROLLABLE INPUTS

An overall average of 70% was used for estimating sediment reduction potential from management related activities. This is based on results from literature and other completed and approved TMDLs. Analysis for two completed sediment TMDLs in California showed that sediment delivery for landslides due to management activity is 60% controllable (U.S. Environmental Protection Agency, Region 9, Redwood Creek TMDL 1998) and 80% controllable (U.S. Environmental Protection Agency, Region 9, Garcia River Sediment TMDL 1998). The recently approved Simpson Northwest Timberlands TMDL in Washington State based estimates of controllable sediment input on these two California TMDLs. Sediment delivery for road surface erosion has been estimated as 70% controllable (Burroughs 1989). Target sediment loading (**Table 32** below) is expressed as tons/mi2/year. The target sediment loading is based on the Stillwater Sciences study data on the lower reach of the North Umpqua River (Stillwater Sciences 2000). The sediment budget for the Tuttle and Engles drainages in Little River was not used due to the small size of the analysis area.

The sediment Loading Capacity was determined by adding the sediment produced under reference conditions to the management-related sediment, and subtracting the controllable inputs (70% of the management-related sediment). The result is greater than reference conditions, because it includes 30% of current management-related sediment. This was adopted as the Loading Capacity because of the uncertainty inherent in assessing sediment quantity and impacts.

Table 32. Sediment Loading Capacity Determination for the Little River Watershed

Sediment Budget	Reference Condition [a] (tons/mi.^{2}/yr)	Current Condition [b] (tons/mi.^{2}/yr)	Management Related (Current Less Reference) (tons/mi.^{2}/yr)	Controllable Inputs [c] (tons/mi.^{2}/yr)	Loading Capacity [d] (tons/mi.^{2}/yr)
Input					
Landslides	125	770	645		
Soil Creep	71	71	0		
Surface Erosion	14	18	4		
Total Inputs	210	859	649	454	405
Output	210	Unknown			
Storage Change	0	Unknown			

[a] Reference condition values from **Table 31** above, Little River column.
[b] Current condition values from **Table 31** above. (Controllable inputs + reference, 649 + 210 = 859)
[c] Controllable inputs = 70 % x management related. 70 % of 649 = 454, amount of reduction potentially resulting from management activities.
[d] Loading Capacity = (management related + reference) - controllable load. An error range is estimated at ±50% for all figures (Stillwater Sciences, 2000).

The calculated Loading Capacity determined above, 405 tons per square mile per year, is a long-term target. This is an average value intended to cover an extended period of time of at least 10 years. The frequency and magnitude of storm events are two major factors delivering the amount of sediment to stream channels. Since these storm events or lack thereof are unpredictable, the Loading Capacity may vary up to 50% from year to year, resulting in a range of 203 to 608 tons per square mile per year that could be delivered to the stream channel. This range falls within the projected reference condition of 210 tons per square mile per year. The variability in predicted sediment delivery from landslides, as taken from the Watershed Analysis, is noted in **Table 19,** and for the most current time period (1982– 1991) is predicted to be 314 tons per square mile per year. The most recent time period prediction indicates a trend toward less sediment being delivered to the stream channel, but that period of sediment delivery does not include storm events of the magnitude of 1964 and 1996.

It is estimated that reducing management-related sediment inputs to an average of 405 tons per square mile per year will, over time, lead to conditions which will attain the narrative criteria for sediment: "The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed." Achieving the Load Allocations will eventually result in a hydrologic regime which is in long-term equilibrium, and will also allow for the removal of sediment built up from past land use practices.

The Little River Watershed will take years to reach what might be considered "equilibrium" until the pulse of sediment generated during the late 1940's and early 1960's is purged from the system. Sediment delivery to the stream channel in Little River varied prior to human land management activities due to naturally occurring events. Components of a sediment budget were always in some state of flux due to these variables. Populations of salmonids and macroinvertebrates endured these “natural” swings in sediment delivery to the Little River Watershed.

The Loading Capacity represents the maximum amount of sediment that the system can absorb and still meet water quality standards. Once the Loading Capacity is determined, it must be allocated according to the formula:

Loading Capacity = Wasteload Allocations + Load Allocations + Background + Margin of Safety

In this case, there are no identified point sources of sediment, so the Wasteload Allocation is 0. Background loading, i.e., loading under reference conditions, is equal to 210 tons per square mile per year. The Margin of Safety, discussed in the next section, is implicit in the calculations, so no discrete figure is used for this component. Therefore, the nonpoint source Load Allocation is calculated as follows:

405 = 0 + LA + 210
LA = 405 – 210 = 195 tons/square mile/year

Since the Load Allocation is a rate per square mile, and not a total volume, the Load Allocation (195 tons per square mile of drainage basin per year) will be the same for all waterbodies throughout the watershed, and will apply to sediment sources from all land uses throughout the watershed. Thus, a Load Allocation of 195 tons per square mile per year is applied to lands managed or regulated by the USFS, BLM, ODF, ODA, and Douglas County.

RELATIONSHIP BETWEEN LOADING ALLOCATIONS AND INSTREAM AND HILLSLOPE TARGETS

The numeric targets discussed earlier (pages Barbara please insert page numbers) are intended to provide readily measurable indicators of progress in achieving conditions supporting beneficial uses protected by the narrative water quality standard. While it is difficult, if not impossible, to accurately measure sediment discharged from a particular landscape, it is possible to use the numeric targets as alternatives to the Loading Allocations for purposes of monitoring progress toward desired conditions. When all numeric targets have been achieved, it is assumed that the Loading Allocations will be met as well. The upslope treatments, together with time for ecosystem response and recovery, are expected to yield the desired results, whether they be expressed as instream and hillslope targets or Loading Allocations. Future monitoring is expected to tighten the link between the numeric targets and Loading Allocations.

Currently there is no baseline data relating to the numeric targets adopted for this TMDL. However, based on narrative salmonid and macroinvertebrate data, it is believed that the current condition falls short of desired values. Future monitoring will establish the baseline and then measure progress towards the numeric targets.

6.8 RESTORATION ACTIONS AND MILESTONES

It is difficult to quantify direct linkages among processes and functions outside the stream channel to in-channel conditions (FEMAT 1993). Due to natural sedimentation, high spatial and temporal variability in weather patterns and mass wasting, and difficulty in measuring sediment delivery/storage/transport in a stream over time, it would be nearly impossible to definitively describe how much sediment a stream can accept and still meet water quality standards. It is also difficult to differentiate and measure the difference between natural and management-related sediment delivery at any specific point or time in the Little River Watershed. We have attempted to characterize sediment sources, assess controllable inputs (i.e., management effects), and develop restoration actions and milestones to address these controllable inputs.

Water quality indicators and restoration activity accomplishments will be used by the federal agencies to track and monitor progress (see Chapter VI, WQRP, Appendix C).

Milestones and priorities for restoration activity are based on addressing the highest existing and at-risk management-related contributors to detrimental sediment delivery and increased peak flows in areas where they will have the most positive effect for the beneficial use (fish). Restoration activities will substantially reduce federal management-related sediment delivery and hydrologic effects and move the sediment budget towards the natural condition on federal lands. **Table 33** provides a summary of actions and milestones relating to hillslope targets.

Table 33. Sediment-Related Restoration Actions and Milestones for Assessing Progress on Hillslope Targets on Federal Land in the Little River Watershed

Parameter	Management Actions (Desired Conditions)	Milestones
Use of clearcut and/or ground-based timber harvest Peak flows	Future harvesting avoids steep inner gorge, unstable, or streamside areas unless a detailed assessment is performed which shows there is no potential for increased sediment delivery to streams as a result. [1] Consider peak flows and hydrologic recovery when planning timber harvest to maintain appropriate canopy closure.	Ongoing
Road location in riparian, inner gorge, or unstable headwall areas	Future roads are not located in riparian, steep inner gorge or unstable headwall areas except where alternatives are unavailable.[2]	Ongoing
Road fill, cutslope, surface, and drainage	Roads have surface and drainage facilities or structures that are appropriate to their patterns and intensity of use. Unstable landings and road fills[3] that could potentially deliver sediment to a stream are pulled back and stabilized.	Review roads (with medium/high sediment delivery in landslide-earthflow areas) to verify the need for restoration and treat or decommission as needed. Treat or decommission other roads as indicated in project level planning efforts.
Road/stream crossings diversion potential, culvert size, and ditch length	Culverts are sized to pass 100-year flood and associated sediment and debris. Install cross drains to reduce ditch length at stream crossings. No crossings have diversion potential.	Review highest risk stream crossings to verify the need for restoration and treat as needed. Treat other stream crossings as indicated in project level planning efforts.

Large woody debris (LWD)	LWD in streams mimics natural conditions. Reintroduce fire into ecosystem.	Place LWD and reintroduce fire based on assessment of local conditions

[1] Characteristics of steep inner gorge, unstable, or streamside areas generally include the following (Redwood Creek TMDL, 1998):
-slopes > 50%
-located within 300 feet of a class 1, 2, or 3 stream
-erosive or incompetent soil type or underlying geology
-concave slope shape
-convergent groundwater present and/or evidence of past movement is present

[2] Steep inner gorge areas generally exceed 65% in slope and are located adjacent to class 1 or 2 streams. Characteristics of steep unstable headwall areas generally include the following (Redwood Creek TMDL, 1998):
-slopes > 50%
-erosive or incompetent soil type or underlying geology
-concave slope shape
-convergent groundwater present and/or evidence of past movement is present

[3]According to the Watershed Analysis, unstable landings and road fills are generally those that are located on slopes >60%.

Similar desired conditions and milestones will also be addressed on remaining lands. There is a collaborative effort to inventory the condition of roads in the Cavitt Creek. BLM, FS and major timberland owner Seneca Timber have completed an inventory and prioritization of work to be performed. Rate of treatments will hinge on available funds. Similar to the evaluation and prioritization process, the land managers are seeking funds in a unified effort.

Similarly, the desired conditions will be addressed on agricultural lands through the Umpqua Basin Agricultural Water Quality Management Area Plan (Appendix D). Please see the accompanying Water Quality Management Plan for additional information regarding the agricultural component.

6.9 IMPLICIT MARGIN OF SAFETY – SEDIMENT

The following comprise the margin of safety implicit in the determination of the sediment TMDL:

- The model (SEDMODL) used for calculating surface erosion from roads overestimates the number of sediment-delivering segments. While it assumes all roads within 200 feet of a stream deliver sediment, this is generally not the case.

- When analyzing rain-on-snow peak flows and potential bank erosion, a conservative assumption was used in estimating hydrologic recovery. It was assumed that forests <40 years of age had no hydrological recovery. In fact, hydrologic recovery of the canopy begins as soon as vegetation is re-established and continues until full recovery is achieved in 30-40 years.

- Proposed changes in riparian vegetation toward larger trees will likely provide, over time, increased large woody debris. Increased large woody debris will increase sediment storage in the streams channels and benefit cool water habitat by increasing the number and depth of pools, along with other changes in channel complexity. These changes were not accounted for in the analysis, and the benefits provide a margin of safety.

- In determining the Loading Capacity, the higher rate of sediment delivery calculated by Stillwater Sciences for the North Umpqua subbasin was used rather than the lower sediment delivery rate calculated by the Umpqua National Forest and the Bureau of Land Management.

- It will take a substantial period of time (at least 10 years) before it will be appropriate to assess whether instream targets and associated water quality standards are being attained. During the period before this assessment can be conducted, significant uncertainty will remain concerning the effectiveness of the TMDL and associated implementation actions. In addition to instream targets, the TMDL includes hillslope targets which identify desired conditions with respect to key land use management practices which could contribute to unacceptable increases in sediment loading rates. It will be possible to monitor whether these hillslope targets are being attained over short periods of time (i.e., less than 10 years). If it is determined that the hillslope targets are not being attained, it will be possible to evaluate whether the TMDL and/or implementation plan require immediate revision. Provision of hillslope factors provides an additional margin of safety to account for the lag time between establishment and implementation of the TMDL and evaluation of its effectiveness.

Overall, collection of site-specific data and refinement of the source analysis in the future will help reduce the uncertainty and eventually allow for fewer conservative assumptions.

6.10 SEASONAL VARIATION AND CRITICAL CONDITIONS

TMDLs by law and regulation must describe how seasonal variations were considered. There is inherent annual and seasonal variation in the delivery of sediment to stream systems. For this reason, the TMDL is designed to apply to the sources of sediment, not the movement of sediment across the landscape.

For sediment, the impairment exists year-round. Sediment inputs are significantly higher during the rainy season, since precipitation mobilizes the sediment and delivers it to the stream. The resulting impairments affect the ability of salmonids to build redds in spawning gravels, and also impair feeding of salmonids, who locate their prey by sight.

The regulations at 40 CFR 130.7 state that TMDLs shall take into account critical conditions for stream flow, loading and water quality parameters. This TMDL does not explicitly estimate critical flow conditions for several reasons. First, unlike many pollutants (e.g., acutely toxic chemicals) sediment impacts on beneficial uses may occur long after sediment is discharged often at locations far downstream from the point of discharge. Second, sediment impacts are rarely correlated closely with flow over short time periods. Third, it is impractical to accurately measure sediment loading, transport, and short term effects during high magnitude flow events which usually produce most sediment loading and channel modifications in systems such as the Little River Watershed. Therefore, the approach used in this TMDL to account for critical conditions is to use indicators that can address sediment sources and watershed conditions addressing lag times from production to delivery, and which are reflective of the net long term effects of sediment loading, transport, deposition, and associated stream flows. Instream indicators may be effectively measured at lower flow conditions at roughly annual intervals, and hillslope indicators can assist in tracking the implementation of measures to improve water quality conditions. Inclusion of a margin of safety helps to ensure that the TMDL will result in beneficial use protection during and after critical flow periods associated with maximum sedimentation events.

Critical conditions concerning stream habitat status and recovery may change substantially following major storms (e.g., storms with a recurrence interval of approximately 50 years or more). Such storms and the associated floods and huge sediment loads can have the effect of changing the channel configuration so dramatically and suddenly that it effectively “recalibrates” the relationships between channel size and flow and sediment conditions for decades to follow. It may be appropriate to reconsider the TMDL and loading allocations after such an event.

7. HABITAT MODIFICATION

The water quality standard for habitat modification is as follows:

Habitat Modification (OAR 340-041-0285(2)(i)):

“The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish shall not be allowed.”

In the Little River Watershed, listings for habitat modification are based on findings in the federal watershed analyses and state stream surveys that a majority of the 2 to 5 order streams in the watershed do not meet either the Large Woody Debris Frequency standard (for 50% of the stream length, there will be 4 or more functional key pieces per 100 meters of stream) and/or Pool Frequency (for 60% of the stream length, there will be no more than 5-8 channel widths between pools).

Habitat modification is not the direct result of a pollutant although it does affect beneficial uses. Because a pollutant is not the cause, the concept of establishing a loading capacity and allocations does not apply. However, habitat modification is addressed in the Water Quality Management Plan portion of these documents. Specifically, it is expected that the improvements to riparian vegetation that will be necessary to meet the temperature and pH targets will also lead to improvements in habitat. Additionally, management actions designed to address the sedimentation issue will also be expected to lead to improved habitat.

8. REASONABLE ASSURANCE OF IMPLEMENTATION

8.1 EXISTING MECHANISMS

There are four mechanisms that are already in place to help assure that this water quality management plan will be implemented:

1. Federal land management is guided by the Northwest Forest Plan which is implemented under the Aquatic Conservation Strategy.

In response to environmental concerns and litigation related to timber harvest and other operations on federal Lands, the United States Forest Service (USFS) and the Bureau of Land Management (BLM) commissioned the Forest Ecosystem Management Assessment Team (FEMAT) to formulate and assess the consequences of management options. The assessment emphasizes producing management alternatives that comply with existing laws and maintaining the highest contribution of economic and social well being. The “backbone” of ecosystem management is recognized as constructing a network of late-successional forests and an interim and long-term scheme that protects aquatic and associated riparian habitats adequate to provide for threatened species and at risk species. Biological objectives of the Northwest Forest Plan include assuring adequate habitat on federal lands to aid the “recovery” of late-successional forest habitat-associated species listed as threatened under the Endangered Species Act and preventing species from being listed under the Endangered Species Act.

2. The state Forest Practices Act (FPA), implemented by the Department of Forestry, regulates forest activities. An interdepartmental review of the FPA will provide the assurance that standards will be met. The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on nonfederal forest lands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe BMP's for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness.

The Oregon Forest Practices Act (FPA, 1994) contains regulatory provisions that include the following objectives: classify and protect water resources, reduce the impacts of clearcut harvesting, maintain soil and site productivity, ensure successful reforestation, reduce forest management impacts to anadromous fish, conserve and protect water quality and maintain fish and wildlife habitat, develop cooperative monitoring agreements, foster public participation, identify stream restoration projects, recognize the value of biodiversity and monitor/regulate the application of chemicals. Oregon’s Department of Forestry (ODF) has adopted Forest Practice Administrative Rules (1997) that clearly define allowable actions on state, county and private forest lands. Forest Practice Administrative Rules allow revisions and adjustments to the regulatory parameters it contains. Several revisions have been made in previous years and it is expected that the ODF, in conjunction with DEQ, will continue to monitor the success of the Forest Practice Administrative Rules. In addition, monitoring activities identified in the accompanying WQMP Element 7 will help determine if management actions are sufficiently protective to meet Effective Shade allocations set by this TMDL and make appropriate revisions that address water quality concerns.

3. Oregon’s Agricultural Water Quality Management Planning Act, ORS 568.900 - 568.933 (SB 1010), sets forth a process for local development of Agricultural Water Quality Management Area Plans to address water quality impairments. In the Umpqua Basin, a Local Advisory Committee together with the Oregon Department of Agriculture have developed an Umpqua Basin Agricultural Water Quality Management Area Plan (Appendix D). This plan, which has undergone public review, has been adopted by the Oregon Board of Agriculture. The plan addresses riparian conditions as well as sediment and nutrient contributions to water quality.

The rules which ODA has adopted are enforceable once they become effective one year after adoption. The SB 1010 process is an enforceable process and administrative rules setting out enforcement procedures and penalties have been adopted as OAR 603-90-0060 through 603-90-0120.

In regard to attaining the temperature allocations, the following rules have been adopted:

OAR 603-095-740 (6) and (7):

(6) Agricultural management or soil-disturbing activities that preclude establishment and

development of adequate riparian vegetation for streambank stability and shading, consistent with site capability, along a perennial stream which has a site potential for such vegetation is considered an unacceptable condition. Minimal breaks in shade vegetation for essential management activities are considered appropriate.

(7) Irrigation practices that contribute significant amounts of warmed surface water (more than 3% of water pumped during any one irrigation setting to return as surface runoff to a stream) back into a stream are considered an unacceptable condition.

Both of these provisions will be important in implementation of the temperature loading allocations, although irrigation is not a major use in the Little River Watershed.

In regard to attaining the pH load allocations, the temperature rules cited above will implement the strategy for reducing pH. In addition, the following rule relates to nutrients:

OAR 603-095-740 (4):

(4) Substantial amounts of phosphorus (i.e., in excess of water quality standards) moving from agricultural lands into waters of the state as a result of agricultural activities is identified as an unacceptable condition.

In regard to attaining the sediment load allocations, OAR 603-095-0740 (6) above will also implement the sediment loading allocations. In addition, the following rule relates to sediment:

OAR 603-095-0740 (3)

(3) Substantial amounts of sediment (i.e., in excess of water quality standards for sedimentation) moving from agricultural lands into waters of the state as a result of agricultural activities is identified as an unacceptable condition. Offstream ponds which do not contribute to the downstream system under normal weather conditions are exempt as they are often used to trap and contain sediment.

These rules, as well as the management practices identified by the Local Advisory Committee (see Appendix D) will provide both the practical and the legal ability to implement the loading allocations in this TMDL as they relate to the agricultural community.

4. There are also many voluntary, non-regulatory, watershed improvement efforts that are already in place and are helping to address the water quality concerns in the Little River Watershed. Both technical expertise and funding are provided through these integrated programs.

An example is the Cavitt Creek Transportation System Assessment, a jointly funded effort coordinated by the Umpqua Basin Watershed Council in which 203.86 miles of forest roads were inspected and hazards to water quality or fish habitat inventoried. Seneca-Jones Timber Company, the largest private landowner in the drainage, participated together with the Umpqua National Forest and the BLM. The DEQ as well as the Oregon Watershed Enhancement Program contributed funding for the project. Based on the inventory, project work has been prioritized and funding is being sought to implement high priority projects.

The State of Oregon has formed a partnership between federal and state agencies, local groups and grassroots organizations, that recognizes the attributes of aquatic health and their connection to the health of salmon populations. The Oregon Plan for Salmon and Watersheds considers the condition of salmon as a critical indicator of ecosystems (CSRI, 1997). The decline of salmon populations has been linked to impoverished ecosystem form and function. Clearly stated, the Oregon Plan has committed the State of Oregon to the following obligations: an ecosystem approach that requires consideration of the full range of attributes of aquatic health, focuses on reversing factors for decline by meeting objectives that address these factors, develops adaptive management and a comprehensive monitoring strategy, and relies on citizens and constituent groups in all parts of the restoration process.

The intent of the Oregon Plan is to conserve and restore functional elements of the ecosystem that support fish, wildlife and people. In essence, the Oregon Plan is distinctly different from the traditional agency approach, and instead, depends on sustaining a local-state-federal partnership. Specifically, the Oregon Plan is designed to build on existing state and federal water quality programs, namely: Coastal Nonpoint Pollution Control Program, the Northwest Forest Plan, Oregon Forest Practices Act, Oregon's Senate Bill 1010 and Oregon's Total Maximum Daily Load Program.

8.2 ADAPTIVE MANAGEMENT

The Little River Watershed TMDL/WQMP is intended to be adaptive. This plan allows for future changes in loading capacities and allocations in the event that scientifically valid reasons demand alterations. It is important to recognize the ongoing study and improvement in understanding of the water quality parameters addressed in this TMDL/WQMP (stream temperature, sedimentation, pH, and habitat modification).

9. PUBLIC PARTICIPATION

During development and in draft these assessment and management plans have been widely presented in the Little River Watershed and the draft document has been made available during development for input and discussion by resource agencies as well as private entities.

A public meeting focusing on the Little River TMDL effort was conducted by DEQ on May 11, 2000, in Glide, the largest community in the watershed.
When the Public Notice of this TMDL is issued, a public information meeting as well as a public hearing will be conducted in the watershed.

Public participation is also addressed in Element 8 of the WQMP.

Below is a copy of the public notice and notice of public hearing for the draft plan issued June 2001.

A responsiveness summary document will be prepared by DEQ in reply to comments received at the public hearing and written comments received within the comment period.

NOTICE OF PUBLIC HEARING

Oregon Department Of Environmental Quality

NOTICE ISSUED: June 4, 2001

Close Of Comment Period: July 16, 2001

Little River Watershed Total Maximum Daily Load and Water Quality Management Plan

PUBLIC PARTICIPATION:	**<u>Public Hearing</u>** The public hearing will be held in **Glide, Oregon, at 7:00 p.m. on Tuesday, July 10, 2001,** at the **Glide Community Center, 20069 North Umpqua Highway, Glide, Oregon.** Before the hearing, there will be an informational presentation beginning at 6:00 p.m. at the same location. **<u>Written comments</u>**: Written comments on the proposed Total Maximum Daily Load and/or Water Quality Management Plan (WQMP) must be received at the Oregon Department of Environmental Quality (DEQ) by **5 p.m. on July 16, 2001**. Written comments should be mailed to Oregon Department of Environmental Quality, Attn: Paul Heberling, 725 SE Main, Roseburg, Oregon 97470. ***People wishing to send comments via e-mail should be aware that if there is a delay between servers or if a server is not functioning properly, e-mails may not be received prior to the close of the public comment period.*** People wishing to send comments via e-mail should send them in Microsoft Word (through version 97), WordPerfect (through version 6.x) or plain text format. Otherwise, due to conversion difficulties, DEQ recommends that comments be sent in hard copy. E-mails should be sent to: Heberling.Paul@deq.state.or.us
WHO IS PROPOSING AN ACTION	Oregon Department of Environmental Quality 811 SW 6th Avenue Portland, Oregon 97204-1390
AREA COVERED BY ACTION	The Little River Watershed, including public and private lands.

WHAT IS PROPOSED:	DEQ proposes to submit the Little River TMDL and WQMP to the U.S. Environmental Protection Agency (EPA) for approval as a total maximum daily load (TMDL) for federal and private lands within the Little River Watershed. EPA approval would remove water quality limited streams covered by the TMDL/WQMP from DEQ's "303d" list of impaired waterbodies. The Little River TMDL and WQMP are based on the Clean Water Act, the Water Quality Restoration Plan for the Little River Watershed prepared by the Roseburg District BLM and the Umpqua National Forest, the Northwest Forest Plan, the Oregon Forest Practices Act, and the proposed Umpqua Basin Agricultural Water Quality Management Plan. *This public hearing addresses only the TMDL and WQMP that are being submitted to EPA*.
WHO IS AFFECTED:	Local public and private land managers, people interested in water quality and fisheries, and people interested in DEQ's implementation of Section 303(d) of the federal Clean Water Act.
NEED FOR ACTION:	Section 303(d) of the federal Clean Water Act requires development of TMDLs for waterbodies included on a state's "303(d)" list. EPA must approve TMDLs submitted by a state.
WHERE TO FIND DOCUMENTS:	The TMDL/WQMP is available for examination and copying at DEQ's Roseburg Office at 725 SE Main, Roseburg, Oregon 97470 and at DEQ's Headquarters Office at Oregon DEQ, Water Quality Division, 811 S.W. 6th Avenue, Portland, OR 97204. Documents are also available on DEQ's web site at http://www.deq.state.or.us. Click on "water quality" then on "water quality program public notices". While not required, scheduling an appointment will ensure documents are readily accessible during your visit. To schedule an appointment in Roseburg contact Paul Heberling at 541-440-3338, x 224. For an appointment in Portland call Dianne Eaton at 503-229-6756 (toll free at 1-800-452-4011) or DEQ's TTY at 503-229-6993. To request copies of the TMDL and WQMP call Paul Heberling or Dianne Eaton at the above numbers. Questions on the proposed TMDL and WQMP should be addressed to Paul Heberling at the above phone number.

ADDITIONAL DOCUMENT LOCATIONS:

Copies of the TMDL/WQMP are also available at:

- Douglas Soil and Water ConservationDistrict
  1443 Vine Street
  Roseburg, OR 97470
  (541) 957-5061

- Umpqua Basin Watershed Council
  1758 NE Airport Road
  Roseburg, OR 97470
  (541) 673-5756

- Douglas County Library and Satellites
  1409 NE Diamond Lake Blvd.
  Roseburg, OR 97470
  (541) 440-4305 or
  800-441-2706

- Roseburg District Bureau of Land Management
  777 NW Garden Valley
  Roseburg, OR 97470
  (541) 440-4930

- Umpqua National Forest
  Glide Ranger District
  Glide, Oregon
  (541) 496-3532

- Umpqua Soil and Water Conservation District
  392 Fir Ave. Suite 104
  Reedsport, OR 97467
  (541) 271-2611

WHAT HAPPENS NEXT:

DEQ will review and consider all comments received during the public comment period. Following this review, the TMDL and WQMP may be sent to U.S. EPA for approval as a TMDL or may be modified prior to submission. You will be notified of DEQ's final decision if you present either oral or written comments during the comment period. If you do not comment but wish to receive notification of DEQ's final decision, please call or write DEQ at the above phone numbers/addresses.

ACCOMMODATION OF DISABILITIES:

DEQ is committed to accommodating people with disabilities. Please notify DEQ of any special physical or language accommodations you may need as far in advance of the hearing date as possible. To make these arrangements, contact Paul Heberling at 541-440-3338, x 224. People with hearing impairments can call DEQ's TTY at 503-229-6993.

ACCESSIBILITY INFORMATION:

This publication is available in alternate format (e.g., large print, Braille) upon request. Please contact DEQ Public Affairs at 503-229-5766 or toll free within Oregon 1-800-452-4011 to request an alternate format. People with a hearing impairment can receive help by calling DEQ's TTY at 503-229-6993.

GLOSSARY

Adaptive Management: An iterative process where policy decisions that are implemented based on scientific experiments that tests the predictions and assumptions specified in a management plan. The results of the experiment are then used to guide policy changes for future management plans.

Anadromous Fish: Species of fish that spawn in fresh water, migrate to the ocean as juveniles, where they live most of their adult lives until returning to spawn in fresh water.

At-Risk Stocks: Anadromous fish species that are identified as requiring special management consideration due to low populations.

Base Flow: Groundwater fed summertime flows that occur in the long-term absence of precipitation.

Beneficial Use: Legislation that requires the reasonable use of water for the best interest of people, wildlife and aquatic species.

Clearcut Harvest: Timber harvests that remove all trees are removed in a single entry from a designated area.

Debris Flow: A rapidly moving congregate of soil, rock fragments, water and trees, where over half of the material in transport has a particle size greater than that of sand.

Decommission: The removal of a road to improve hillslope drainage and stabilize slope hazards.

Endangered Species: A species that is declared by the Endangered Species Act (ESA) to be in danger of extinction throughout a significant portion of its range.

Fire Regime: The frequency, extent, intensity and severity of naturally occurring seasonal fires in an ecosystem.

Flood Plain: Areas bordering a stream that become inundated with flood waters.

Groundwater: Subsurface water that completely fills the porous openings is soil and rocks.

Large Woody Debris: Pieces of wood in the active channel greater than 50 feet in length and 2 feet in diameter.

Mass Movement: The movement of soil due to gravity, such as: landslides, debris avalanches, rack falls and creep.

pH: A measure of the hydrogen ion concentration is aqueous solutions. Acidic solutions have a pH less than 7, neutral solutions have a pH of 7, and basic solutions have a pH that is greater than 7.

Peak Flow: The largest flow volume occurring in one year due to one storm event.

Redd: An anadromous fish nest made in the gravel substrate of a stream where a fish will dig a depression, lay eggs in the depression and cover it forming a mound of gravel.

Riparian Area: A geographic area that contains the aquatic ecosystem and the upland areas that directly affect it. Also defined as 360 feet from a fish bearing stream and 180 feet from a non-fish bearing stream.

Sac Fry: Larval salmonid that has hatched, but has not fully absorbed the yolk sac and has not emerged from the redd.

Seral Stage: Refers to the age and type of vegetation that develops from the stage of bare ground to the climax stage.

- ***Early Seral Stage***: The period from bare ground to initial crown closure (grass, shrubs, forbs, brush).
  - ***Mid Seral Stage***: The period of a forest stand from crown closure to marketability (young stand of trees from 25 to 100 years of age, includes hardwood stands).
- ***Late Seral Stage***: The period of a forest stand from marketability to the culmination of the mean annual increment (mature stands of conifers and old-growth).

Smolt: Juvenile salmonid one or two years old that has undergone physiological changes adapted for a marine environment. Generally, the seaward migrant stage of an anadromous fish species.

Soil Compaction: Activities/processes, vibration, loading, pressure, that decrease the porosity of soils by increasing the soil bulk density $\left(\frac{\text{Weight}}{\text{UnitVolume}}\right)$.

Surface Erosion: Detachment, entrainment, and transport of soil particles by wind and water**.**

Threatened Species: Species that are likely to become endangered through their normal range within the foreseeable future.

Watershed: A drainage basin that contributes water, organic material, dissolved nutrients, and sediment to streams, rivers, and lakes.

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DRAFT
LITTLE RIVER WATERSHED
WATER QUALITY MANAGEMENT PLAN (WQMP)

Prepared by: Oregon Department of Environmental Quality
April 2001

State of Oregon
Department of Environmental Quality

Submissions by: Oregon Dept. of Forestry
Oregon Dept. of Agriculture
Cities/Counties
Oregon Department of Transportation
Oregon Water Resources Department
Forest Service
BLM

CHAPTER 1 - INTRODUCTION

This document is intended to describe strategies for how the Little River Watershed Total Maximum Daily Loads (TMDLs) will be implemented and, ultimately, achieved. The main body has been prepared by the Oregon Department of Environmental Quality (DEQ) and includes a description of activities, programs, legal authorities, and other measures for which DEQ and the watershed's designated management agencies (DMAs) have regulatory responsibilities. This Water Quality Management Plan (WQMP) is the overall framework describing the management efforts to implement the Little River Watershed TMDLs. Appended to this document are DMA-specific Implementation Plans which describe each DMA's existing or planned efforts to implement their portion of the TMDLs. This relationship is presented schematically in **Figure 1**, below.

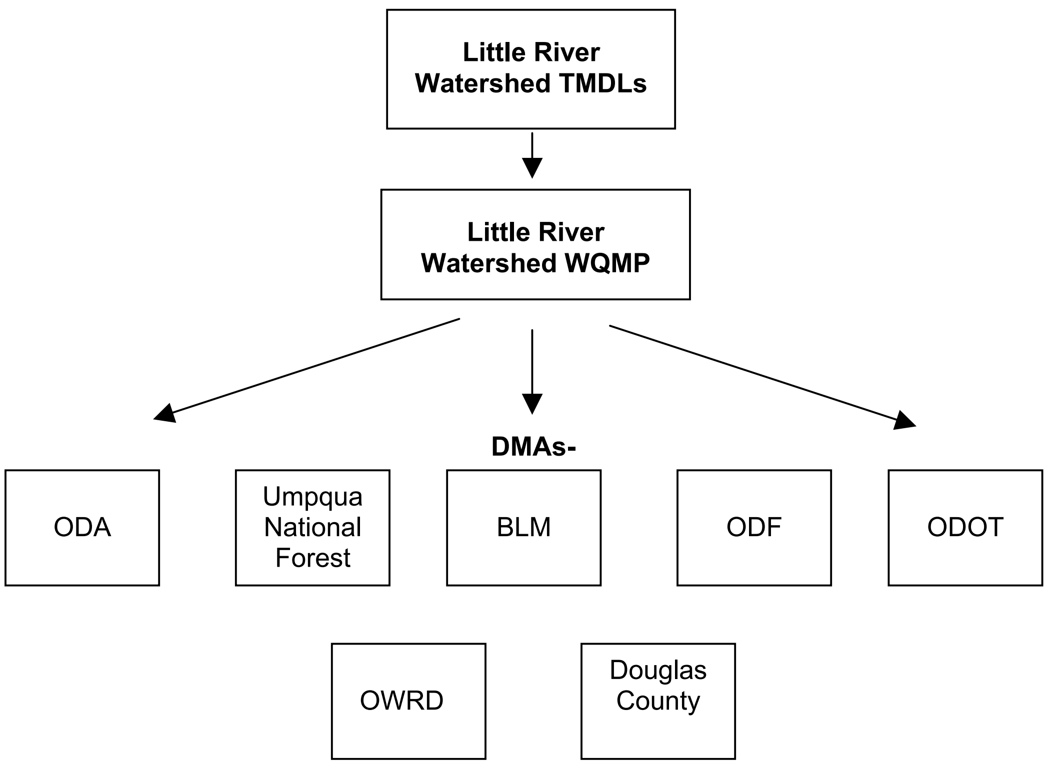


Figure 1. TMDL/WQMP/Implementation Plan Schematic

Four of the DMAs named in the Little River Watershed TMDLs (Umpqua National Forest, BLM, ODOT and ODF) have submitted preliminary Implementation Plans that are appended to this document. In addition, an Agricultural Water Quality Management Area Plan has been produced by the Department of Agriculture Other DMAs have not yet completed Implementation Plans. These Implementation Plans, when complete, are expected to fully describe DMA efforts to achieve their appropriate allocations, and ultimately, water quality standards. Since the DMAs will require some time to fully develop these Implementation Plans once the TMDLs are finalized, the first versions of the Implementation Plans are not expected to completely describe management efforts.

DEQ recognizes that TMDL implementation is critical to the attainment of water quality standards. Additionally, the support of DMAs in TMDL implementation is essential. In instances where DEQ has no direct authority for implementation, it will work with DMAs on implementation to assure attainment of the TMDL allocations and, ultimately, water quality standards. Where DEQ has direct authority, it will use that authority to assure attainment of the TMDL allocations (and water quality standards).

This document is the first version of the Water Quality Management Plan (WQMP) for the new Little River Watershed TMDLs. As explained in “Element 6” of this document, DMA-specific Implementation Plans will be more fully developed once the current TMDLs are submitted to the U. S. Environmental Protection Agency (EPA) and approved. This WQMP will establish proposed timelines (following final TMDL approval) to develop full Implementation Plans. DEQ and the DMAs will work cooperatively in the development of the TMDL Implementation Plans and DEQ will ensure that the plans adequately address the elements described below under “TMDL Water Quality Management Plan Guidance”. In short, this document is a starting point and foundation for the WQMP elements being developed by DEQ and Little River Watershed DMAs.

IMPLEMENTATION AND ADAPTIVE MANAGEMENT ISSUES

The goal of the Clean Water Act and associated Oregon Administrative Rules is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where nonpoint sources are the main concern. To achieve this goal, implementation must begin as soon as possible.

TMDLs are numerical loadings that are set to limit pollutant levels so that instream water quality standards are met. DEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is also recognized that there is a varying level of uncertainty in the TMDLs depending on factors such as amount of data this is available and how well the processes listed above are understood. It is for this reason that the TMDLs have been established with a margin of safety. Subject to available resources, DEQ will review and, if necessary, modify TMDLs established for a subbasin on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDLs are needed.

Water Quality Management Plans (WQMPs) are plans designed to reduce pollutant loads to meet TMDLs. DEQ recognizes that it may take some period of time - from several years to several decades - after full implementation before management practices identified in a WQMP become fully effective in reducing and controlling certain forms of pollution such as heat loads from lack of riparian vegetation. In addition, DEQ recognizes that technology for controlling some pollution sources such as nonpoint sources and stormwater is, in many cases, in the development stages and will likely take one or more efforts to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established. **Figure 2** is a graphical representation of this adaptive management concept.

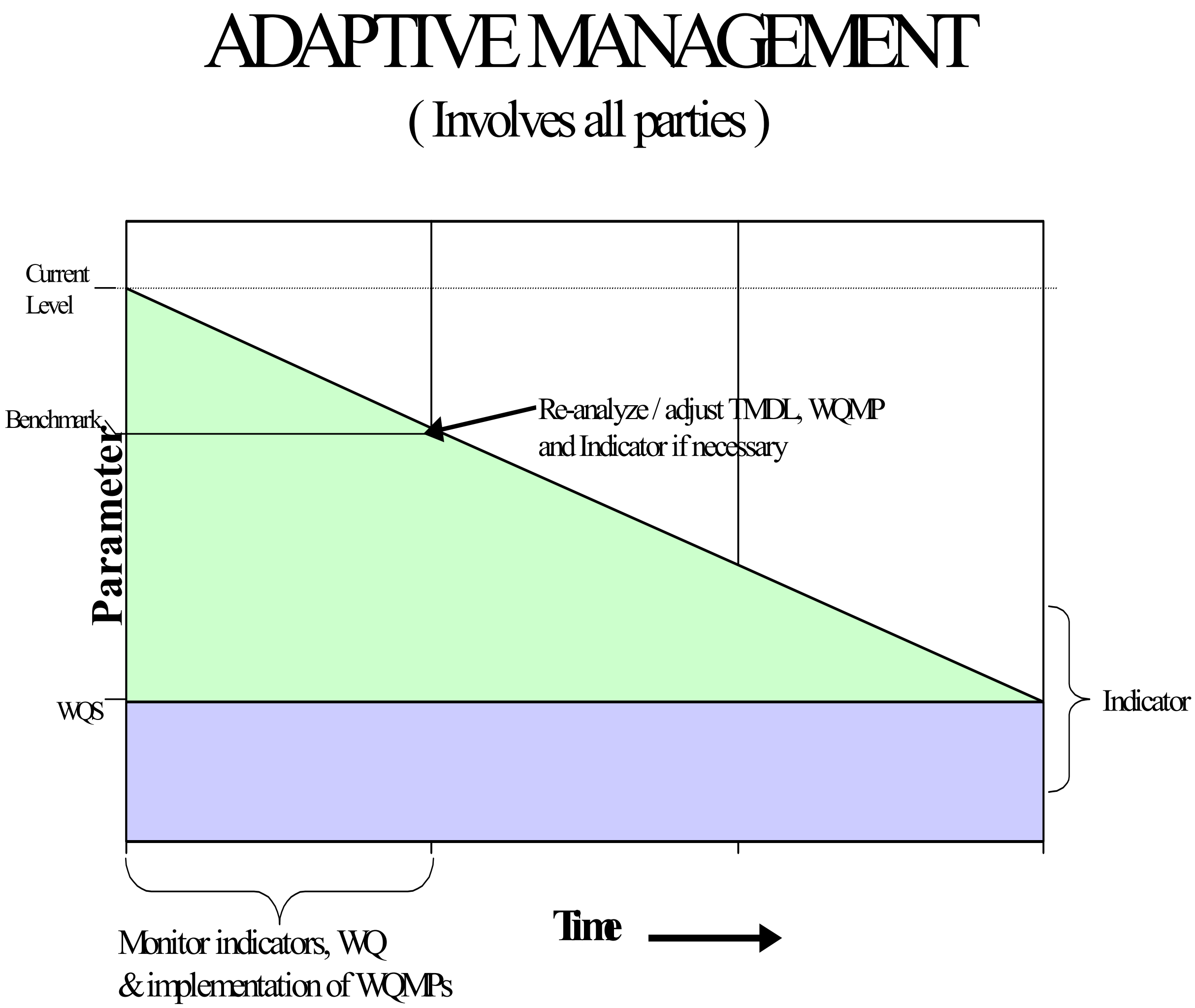


Figure 2. Conceptual Representation of Adaptive Management

DEQ also recognizes that, despite the best and most sincere efforts, natural events beyond human control may interfere with or delay attainment of the TMDL and/or its associated surrogates. Examples are floods, fire, insect infestations, and drought.

In the Little River Watershed TMDLs, pollutant surrogates have been defined as alternative targets for meeting the TMDLs for some parameters. The purpose of the surrogates is not to bar or eliminate human access or activity in the basin or its riparian areas. It is the expectation, however, that WQMPs will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, WQMPs should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the wasteload allocation (40 CFR 122.44(d)(1)(vii)(B)). Similarly, the Department will work with nonpoint sources in developing management plans that are consistent in meeting the assumptions and requirements of the load allocations. These permits and plans will be developed/modified within 1-2 years following the development/modification of a TMDL and include but not be limited to the following (February 2000 MOA between DEQ and EPA):

- Management measures tied to attainment of the TMDL,
- Timeline for implementation (including appropriate incremental measurable water quality targets and milestones for implementing control actions),
- Timeline for attainment of water quality standards including an explanation of how implementation is expected to result in the attainment of water quality standards,
- Monitoring and evaluation.

If a source that is covered by the TMDL complies with its permit, WQMP, or applicable forest practice rules, it will be considered in compliance with the TMDL.

DEQ intends to regularly review progress of WQMPs to achieve TMDLs. If and when DEQ determines that the WQMP has been fully implemented, that all feasible management practices have reached maximum expected effectiveness and a TMDL or its interim targets have not been achieved, the Department shall reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance (OAR 340-041-026(3)(D)(ii)).

The implementation of TMDLs and the associated plans is generally enforceable by DEQ, other state agencies and local government. However, it is envisioned that sufficient initiative exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers and permit holders to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. In the case of nonpoint sources, this could occur first through direct intervention from land management agencies (e.g., ODF, ODA, counties and cities), and secondarily through DEQ. The latter may be based on departmental orders to implement management goals leading to water quality standards.

A zero waste load allocation does not necessarily mean that a point source is prohibited from discharging any wastes. A source may be permitted to discharge by DEQ if the holder can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when system temperature is achieved. Or, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source could be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

Adaptive Management

In employing an adaptive management approach to this TMDL and WQMP, DEQ has the following expectations and intentions:

Subject to available resources, DEQ will review and, if necessary, modify TMDLs and WQMPs established for a subbasin on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDL are needed. In conducting this review, DEQ will evaluate the progress towards achieving the TMDLs (and water quality standards) and the success of implementing the WQMP.

When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the wasteload allocation (40 CFR 122.44(d)(1)(vii)(B)).

DEQ expects that each management agency will also monitor and document its progress in implementing the provisions of its component of the WQMP. This information will be provided to DEQ for its use in reviewing the TMDL.

As implementation of the WQMP proceeds, DEQ expects that management agencies will develop benchmarks for attainment of TMDL surrogates, which can then be used to measure progress.

Where implementation of the WQMP or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise their component of the WQMP to address these deficiencies.

When DEQ, in consultation with the management agencies, concludes that all feasible steps have been taken to meet the TMDL and its associated surrogates and attainment of water quality standards, the TMDL, or the associated surrogates is not practicable, it will reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance (OAR 340-41-026(3)(a)(D)(ii)).

CHAPTER 2 - TMDL WATER QUALITY MANAGEMENT PLAN GUIDANCE

In February, 2000, DEQ entered into a Memorandum of Agreement (MOA) with the U.S. Environmental Protection Agency (EPA) that describes the basic elements needed in a TMDL Water Quality Management Plan (WQMP). That MOA was endorsed by the Courts in a Consent Order signed by United States District Judge Michael R. Hogan in July, 2000. These elements, as outlined below, will serve as the framework for this WQMP.

WQMP Elements

Condition assessment and problem description
Goals and objectives
Identification of responsible participants
Proposed management measures
Timeline for implementation
Reasonable assurance
Monitoring and evaluation
Public involvement
Costs and funding
Citation to legal authorities

This Little River Watershed WQMP is organized around these plan elements and is intended to fulfill the requirement for a surface water temperature management plan contained in OAR 340-041-0026(3)(a)(D).

CHAPTER 3 – CONDITION ASSESSMENT AND PROBLEM DESCRIPTION

GEOGRAPHIC REGION OF INTEREST

The Umpqua River Basin in western Oregon is the eleventh largest drainage basin in Oregon, covering an area of about 4,560 square miles in the southwestern section of the state. The basin boundaries coincide closely with those of Douglas County. The Umpqua Basin is bounded on the north by the Siuslaw and Willamette Basins, on the east by the Deschutes and Klamath Drainage Basins, on the south by the Rogue Drainage Basin, and on the west by the Coos and Coquille River watersheds and the Pacific Ocean. The western portion of the basin is underlain by marine sedimentary rocks and the eastern portion by volcanic igneous rocks. Metamorphic rocks form a small area in the south-central area. The relief extends from sea level to 9,182-foot Mt. Thielsen, a part of the Cascade Range, on the eastern border. Slope is highly variable within the basin, from the steepest and most dissected in the state (western basin) to gently rolling hills and valleys around Roseburg.

The Umpqua River empties into the Pacific Ocean near the City of Reedsport. The Umpqua River system divides west of Roseburg into north and south forks The mainstem Umpqua is about 112 miles long. From the junction of the two forks, the North Umpqua River is about 106 miles long to Diamond Lake, while the South Umpqua River is about 104 miles long to the headwaters of Castle Rock Creek at the Rogue-Umpqua Divide.

Climatic conditions in the basin are determined mostly by the Pacific Ocean weather fronts which cause cloudy and rainy winters and warm, dry summers. Precipitation is lighter along the coast and greater in the mountains, with averages ranging widely from 25 to over 100 inches annually.

Most of the land in the basin (88.9%) is classified as forest land. Agricultural lands, including irrigated and nonirrigated croplands and rangelands comprise 7.5% of the basin area.

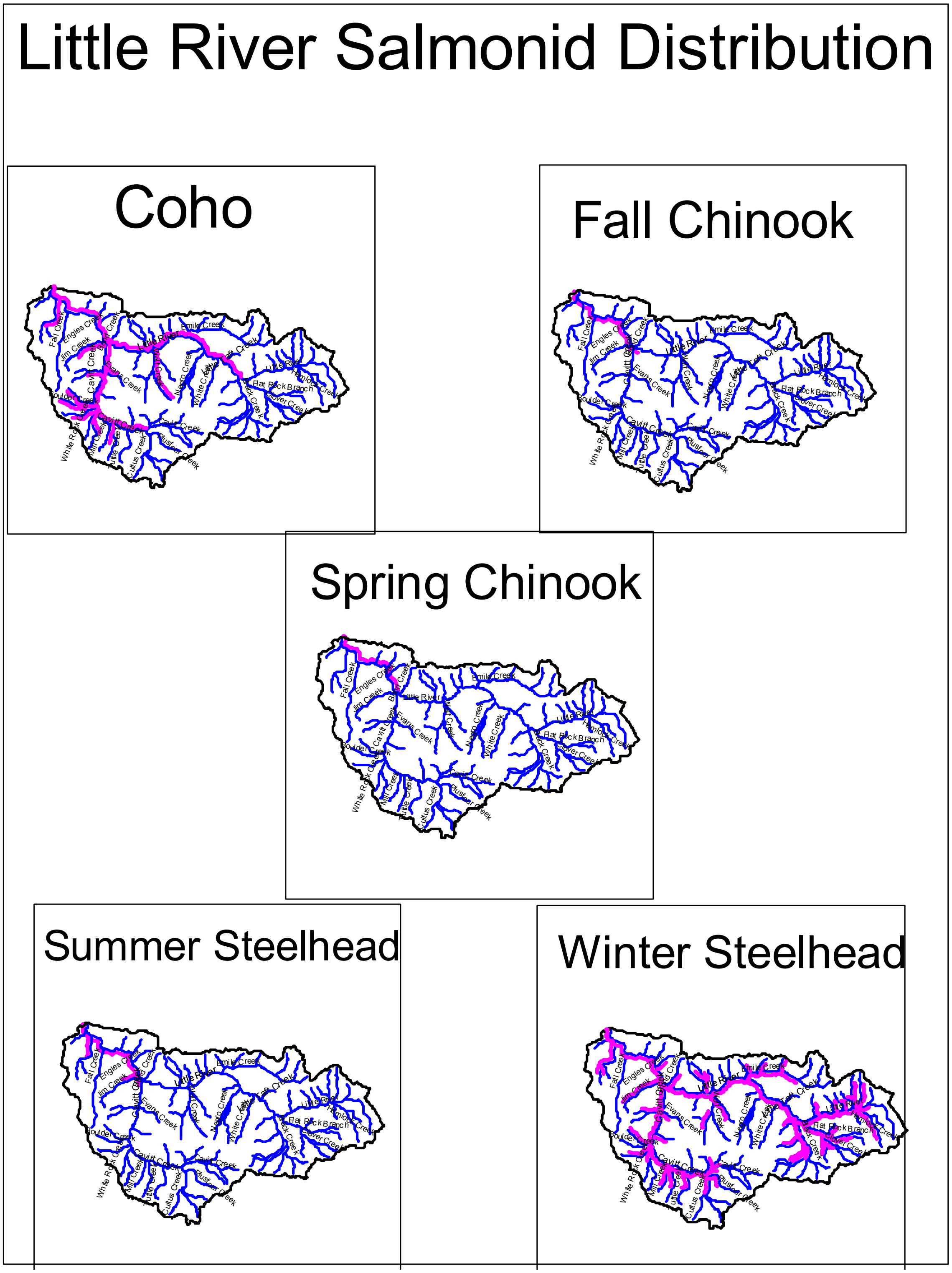
The Little River subbasin is located 18 miles east of Roseburg, Oregon, in an area that spans the eastern fringe of the Coastal range, the Umpqua valley, and the Cascade range. It is one of the largest tributaries to the North Umpqua River, and covers an area of 131,853 acres. Elevations in the subbasin vary between 750 to 5,275 feet. The mid to upper portions of the subbasin consist of coniferous forests, while the lower elevations are comprised of vegetation commonly found in the Umpqua valley hills: mixed hardwoods, prairies, and conifers.

Timber production is the dominant land use activity in the Little River subbasin. Sixty-three percent of the watershed is administered by the USDA Forest Service and the Bureau of Land Management. This public land is designated an Adaptive Management Area (AMA), where one of several goals is to integrate intensive timber production with the restoration and maintenance of riparian habitat. The remaining 37% of the land consists of private lands, much of which is managed as industrial forest. The present condition of the species composition and age of vegetation is heavily impacted by the widespread harvesting and replanting that has occurred since the 1950’s. Nearly sixty percent of the watershed has been harvested and replanted.

Other land use activities within the Little River Watershed include road construction and maintenance, water extraction, agricultural land use and recreation. Currently, 1,200 people live in the Little River Watershed and many of the residents withdraw water from the river and its tributaries for domestic and irrigation uses. A total of 111 domestic water rights and 109 irrigation rights have been issued by the State of Oregon. Roads and stream crossings (bridges and culverts) are densely distributed throughout the entire watershed. Ranches and small farms can be found in the rural lower portions of the watershed. The Little River subbasin is a destination for many forms of recreation, including fishing, swimming, and hiking.

Little River supports a diverse assemblage of fish species, including six stocks of anadromous salmonids (spring and fall chinook, coho, winter and summer steelhead trout, and searun cutthroat trout) and Pacific lamprey. Based on the large numbers of juvenile salmon leaving the Little River, this system is one of the most important tributaries to the North Umpqua in terms of spawning and rearing habitat. Historically, Little River was the most significant coho salmon spawning tributary in the entire North Umpqua basin. There currently exist several miles of spawning habitat for spring chinook salmon. Little scientific information is available concerning the Pacific lamprey. The fish species distribution found in the Little River Watershed is presented in **Figure 3.**

Figure 3. Salmonid Distribution Within the Little River Sub Basin



Coho in the Umpqua Basin have been listed as threatened under the Endangered Species Act (ESA). Coastal cutthroat trout, previously listed as endangered, are now considered to be part of a larger genetic unit. Coastal cutthroat trout within the larger unit has been designated as a candidate species for listing under the ESA.

BENEFICIAL USES

Oregon Administrative Rules (OAR Chapter 340, Division 41, Table 3) list the "Beneficial Uses" occurring within the Umpqua Basin (**Table 1**). Numeric and narrative water quality standards are designed to protect the most sensitive beneficial uses.

Table 1. Beneficial uses occurring in the Little River Watershed

(OAR 340 – 041 – 0282)

Beneficial Use	*Occurring*	*Beneficial Use*	*Occurring*
Public Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Private Domestic Water Supply	✓	Salmonid Fish Rearing	✓
Industrial Water Supply	✓	Resident Fish and Aquatic Life	✓
Irrigation	✓	Anadromous Fish Passage	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Hydropower		Commercial Navigation and Transportation	

CURRENT CONDITIONS

The Little River Watershed has stream segments listed on the 1998 Oregon 303(d) List for:

Stream	Parameter
Black Creek mouth to headwaters	Temperature
Cavitt Creek mouth to Plusfour Cr.	Hab. Mod., Sed., Temp.
Cavitt Creek mouth to Evarts Cr.	pH
Clover Creek mouth to headwaters	Temperature
Eggleston Creek mouth to headwaters	Temperature
Emile Creek mouth to headwaters	Temperature
Emile Creek mouth to RM 1	pH
Flat Rock Creek mouth to headwaters	Temperature
Jim Creek mouth to RM 2	Temperature
Little River mouth to Hemlock Cr.	Hab. Mod., Sed., Temp.
Little River mouth to White Cr.	pH
Little River Hemlock Cr. to Headwaters	Sed., Hab. Mod.
Wolf Creek mouth to major falls	Temp., pH
Wolf Creek mouth to headwaters	Temperature

EXISTING SOURCES OF WATER POLLUTION

TEMPERATURE

Riparian vegetation, stream morphology (structure), hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, the condition of the riparian area, channel morphology and hydrology can be affected by local land use activities. Specifically, elevated summertime stream temperatures may result from the following conditions within the Little River Watershed:

- Riparian vegetation disturbance that reduces stream surface shading, riparian vegetation height, and riparian vegetation density (shade is commonly measured as percent effective shade),

- Channel widening (increased width to depth ratios) due to factors such as loss of riparian vegetation, increasing the surface area exposed to solar radiation,

- Reduced flow volumes (from residential and irrigation withdrawals), and

- Disconnected floodplains which prevent/reduce groundwater discharge into the river.

EUTROPHICATION

pH

The pH of a body of water is based on the number of hydrogen ions in that water. This in turn is based upon a number of factors, including temperature, presence of nutrients, presence of algal communities, and the presence or absence of natural buffering compounds in the stream.

In the Little River Watershed, there are some nutrient sources, but scientific study has determined that if stream temperatures are reduced sufficiently, the pH will also be reduced enough in the Little River to meet water quality standards. Therefore, while the following are potential sources of nutrients, the primary strategy for meeting the pH standard will be through temperature control.

1. **Wastewater Treatment Plants and Sanitary Sewer Systems**

There is only one domestic wastewater treatment plant in the watershed, at the Wolf Creek Conservation Corps. Analysis has indicated that this treatment facility is not having any adverse impacts on water quality in the Little River. See pH TMDL, Chapter 5.

2. **Urban and Rural Runoff**

Urban runoff can be quite high in total phosphorus concentrations. The sources could include fertilizers, erosion, cross-connections, etc. In the Little River, there are few truly urban areas. The major populations centers are Glide and Peel.

Rural runoff may contain phosphorus from the same sources as urban runoff. Additional potential sources are small farms, horse pastures, and small ranches. These sites are often stocked very densely and may have poor management.

3. **Agricultural Runoff**
Some of the potential sources of phosphorus in agricultural runoff are fertilizers, animal waste, and erosion.

4. **Forestry Runoff**
Since surface runoff in forested areas during the summer, when streams are listed for pH, is expected to be minimal, phosphorus loads from forestry operations are most likely predominately associated with roads and culverts.

5. **Failing Septic Systems**
Effluent from failing septic systems will contain phosphorus, along with bacteria, BOD and other pollutants.

6. **Instream and Near-stream Erosion**
Phosphorus contained in soils may be transported to the critical segments of the Little River through instream and near-stream erosion. While a certain amount of this erosion is natural, some erosion (especially during the summer) is not.

SEDIMENTATION

Sediment, as it relates to water quality, refers to particles of varying size, from small clay particles to car-sized rocks. Sedimentation is a natural product of a healthy ecosystem, and provides some of the material needed for aquatic habitat such as spawning gravels for salmonids. However, excessive sedimentation can have a variety of adverse impacts on water quality.

Riparian vegetation, stream morphology (structure), hydrology, climate and weather influence sedimentation rates. Increased erosional processes resulting from human activities also influence sedimentation rates. Any disturbance has the potential to increase sedimentation; roads, timber harvest, removal of riparian vegetation leading to streambank erosion, increased peak flows due to harvest or increased impervious surfaces are all common disturbances in the Little River Watershed.

HABITAT MODIFICATION

Several streams in the Little River Watershed are listed for habitat modification based on a Watershed Analysis conducted by the federal agencies. While formal TMDLs are not required for this listing parameter, the Water Quality Restoration Plan (Appendix C) developed by the federal agencies addresses habitat modification.

CHAPTER 4 – GOALS AND OBJECTIVES

The overall goal of the TMDL Water Quality Management Plan (WQMP) is to achieve compliance with water quality standards for each of the 303(d) listed parameters and streams in the Little River Watershed. Specifically, the WQMP combines a description of all Designated Responsible Participants (or Designated Management Agencies (DMA)) plans that are or will be in place to address the load allocations in the TMDL. The specific goal of this WQMP is to describe a strategy for reducing discharges from nonpoint sources to the level of the load allocations described in the TMDL. As discussed above, this plan is preliminary in nature and is designed to be adaptive as more information and knowledge is gained regarding the pollutants, allocations, management measures, and other related areas.

The expectation of all DMAs is to:

1. Develop Best Management Practices (BMPs) or methodologies to achieve Load Allocations and Waste Load Allocations;

2. Give reasonable assurance that management measures will meet load allocations; through both quantitative and qualitative analysis of management measures;

3. Adhere to measurable milestones for progress;

4. Develop a timeline for implementation, with reference to costs and funding;

5. Develop a monitoring plan to determine if:
   - Measures are being implemented;
   - Individual measures are effective;
   - Load and wasteload allocations are being met;
   - Water quality standards are being met.

CHAPTER 5 - IDENTIFICATION OF RESPONSIBLE PARTICIPANTS

The purpose of this element is to identify the organizations responsible for the implementation of the plan and to list the major responsibilities of each organization. What follows is a simple list of those organizations and responsibilities. This is not intended to be an exhaustive list of every participant that bears some responsibility for improving water quality in the Little River Watershed. Because this is a community wide effort, a complete listing would have to include every business, every industry, every farm, and ultimately every citizen living or working within the watershed. We are all contributors to the existing quality of the waters in the Little River Watershed and we all must be participants in the efforts to improve water quality.

Oregon Department of Environmental Quality

- NPDES Permitting and Enforcement
- WPCF Permitting and Enforcement
- Technical Assistance
- Financial Assistance

Oregon Department of Agriculture

- Agricultural Water Quality Management Plan Development, Implementation & Enforcement.
- CAFO Permitting and Enforcement
- Technical Assistance
- Revise Agricultural WQMAP Rules under Senate Bill (SB) 1010 to clearly address TMDL Load Allocations as necessary
- Riparian area management

Oregon Department of Forestry

- Forest Practices Act (FPA) Implementation
- Conservation Reserve Enhancement Program
- Revise statewide FPA rules and/or adopt watershed specific rules as necessary.
- Riparian area management

Oregon Department of Transportation

- Routine Road Maintenance, Water Quality and Habitat Guide Best Management Practices
- Pollution Control Plan and Erosion Control Plan
- Design and Construction
-

Federal Land Management Agencies (Forest Service and BLM)

- Implementation of Northwest Forest Plan
- Wolf Creek Sewage Treatment Plan –
  Operation and maintenance of wastewater treatment plant
  Riparian Area Management

Douglas County

- Construction, operation and maintenance of County roads and storm sewer system
- Land use planning, permitting
- Maintenance, construction and operation of parks and other county owned facilities and infrastructure
- Riparian area management

Oregon Water Resources Department

- Water rights program administration and enforcement
- Leasing of instream water rights
- Water conservation program administration

Table 2, shows Little River Watershed 303d listed stream segments along with the responsible Designated Management Agencies.

Table 2. Geographic Coverage of Designated Management Agencies

Stream	Segment	TMDL Parameters	Designated Management Agencies
Black Creek	Mouth to Headwaters	Temperature	UNF,OWRD
Cavitt Creek	Mouth to Plusfour Cr.	Habitat Modification, Sedimentation, Temperature	BLM, UNF, ODA, ODF, Doug, OWRD
Cavitt Creek	Mouth to Evarts Cr.	pH	BLM, ODA, ODF, Doug, OWRD
Clover Creek	Mouth to Headwaters	Temperature	BLM, UNF, OWRD
Eggleston Creek	Mouth to Headwaters	Temperature	BLM, UNF, ODA, ODF, Doug, OWRD
Emile Creek	Mouth to Headwaters	Temperature	BLM, UNF, ODA, ODF, Doug, OWRD
Emile Creek	Mouth to River Mile 1.0	pH	BLM, UNF, ODA, ODF, Doug, OWRD
Flat Rock Creek	Mouth to Headwaters	Temperature	BLM, UNF, OWRD
Jim Creek	Mouth to River Mile 2.0	Temperature	BLM, ODA, ODF, Doug, OWRD
Little River	Mouth to Hemlock Creek	Habitat Modification, Sedimentation, Temperature	BLM, UNF, ODA, ODF, Doug, OWRD
Little River	Mouth to White Creek	pH	BLM, UNF, ODA, ODF, Doug, OWRD
Little River	Hemlock Creek to Headwaters	Sedimentation, Habitat Modification	UNF, OWRD
Wolf Creek	Mouth to major falls	pH, Temperature	BLM, OWRD
Wolf Creek	Mouth to Headwaters	Temperature	BLM, OWRD

*Notes: Temperature is listed for summer.
BLM = Bureau of Land Management, Roseburg District; UNF = Umpqua National Forest; ODA = Oregon Department of Agriculture; ODF = Oregon Department of Forestry; Doug = Douglas County; OWRD = Oregon Water Resources Department

CHAPTER 6 – PROPOSED MANAGEMENT MEASURES

This section of the plan outlines the proposed management measures that are designed to meet the wasteload allocations and load allocations of each TMDL. The timelines for addressing these measures are given below.

The management measures to meet the load and wasteload allocations may differ depending on the source of the pollutant. Given below is a categorization of the sources and a description of the management measures being proposed for each source category.

Wastewater Treatment Plant
The Wolf Creek Sewage Treatment Plant effluent has been determined not to be a source of pollution. It must adhere to present and future permit requirements and will not be required to develop other specific management measures.

General and Minor Individual NPDES Permitted Sources
All general NPDES permits and minor individual NPDES permits will be reviewed and, if necessary, modified to ensure compliance with allocations. Either numeric effluent limits will be incorporated into the permits or specific management measures and plans will be developed.

Other Sources
For discharges from sources other than point sources requiring NPDES permits, DEQ has assembled an initial listing of management categories. This listing, given in **Table 3** below, is designed to be used by the designated management agencies (DMAs) as guidance for selecting management measures to be included in their Implementation Plans. Each DMA will be responsible for examining the categories in **Table 3** to determine if the source and/or management measure is applicable within their jurisdiction. This listing is not comprehensive and other sources and management measures will most likely be added by the DMAs where appropriate. Alternatively, not all of the measures may be appropriate for every geographic area. Little River has few urban areas, for example. For each source or measures deemed applicable, a listing of the frequency and extent of application should also be provided. In addition, each of the DMAs is responsible for source assessment and identification, which may result in additional categories. It is crucial that management measures be directly linked with their effectiveness at reducing pollutant-loading contributions.

Table 3. Management Categories Sorted by Pollutant Source and/or anagement Measures

Management Measure/Source Category		Sedimentation	Temperature	pH
		Standard/Parameter		
Public Awareness/Education		X	X	X
General Outreach				
Targeted Outreach				
New Development and Construction				
Planning Procedures			X	X
Permitting/Design			X	X
Education and Outreach			X	X
Construction Control Activities			X	X
Procedures/Measures				
Inspection/Enforcement				
Post-Construction Control Activities		X	X	X
Procedures/Measures				
Inspection/Enforcement				
Storm Drain System Construction				
Existing Development				
Streets & Roads				
Street Sweeping		X		X
Maintenance Activities				X
Septic Systems				
Procedures/Measures				X
Inspection/Enforcement				X
Parking Lots		X	X	X
Commercial and Industrial Facilities		X	X	X
Source Control				
Fertilizers				X
Pet Waste		X		X
Other				

Table 3 (Continued). Management Categories Sorted by Pollutant Source and/or Management Measures

		Parameter		
Management Measure/Source Category		Sedimentation	Temperature	pH
Illicit Connections and Illegal Dumping				
Residential				
Illegal Dumping		X		X
Illicit Discharges and Cross Connections		X		X
Commercial and Industrial				
Illegal Dumping		X		X
Illicit Discharges and Cross Connections		X		X
Riparian Area Management				
Revegetation			X	X
Streambank Stabilization				X
Public/Governmental Facilities				
Parks		X		X
Public Waterbodies (Ponds, etc.)		X		
Municipal Corporation Yard O&M		X	X	X
Other Public Buildings and Facilities		X	X	X
Forest Practices				
Riparian Area Management		X	X	X
Roads/Culverts		X		X
Agricultural Practices				
Riparian Area Management		X	X	X
Erosion Control		X		X
Animal Waste		X		X
CAFOs				
Other				
Nutrient Management				X
Planning and Assessment		X	X	X
Source Assessment/Identification		X	X	X
Source Control Planning		X	X	X
Monitoring and Evaluation		X	X	X
BMP Monitoring and Evaluation		X	X	X
Instream Monitoring		X	X	X
BMP Implementation Monitoring		X	X	X
Transportation		X	X	X
Road Construction, Maintenance and Repair		X	X	X

CHAPTER 7 – TIMELINE FOR IMPLEMENTATION

The purpose of this element of the WQMP is to demonstrate a strategy for implementing and maintaining the plan and the resulting water quality improvements over the long term. Included in this section are timelines for the implementation of DEQ activities. Each DMA-specific Implementation Plan will also include timelines for the implementation of the milestones described earlier. Timelines should be as specific as possible and should include a schedule for BMP installation and/or evaluation, monitoring schedules, reporting dates and milestones for evaluating progress.

The DMA-specific Implementation Plans are designed to reduce pollutant loads from sources to meet TMDLs, associated loads and water quality standards. DEQ recognizes that where implementation involves significant habitat restoration or reforestation, water quality standards may not be met for decades. In addition, technology for controlling nonpoint source pollution is, in some cases, in the development stages and will likely take one or more versions to develop effective techniques.

For some Little River Watershed TMDLs, pollutant surrogates have been defined as alternative targets for meeting the TMDL for some parameters. The purpose of the surrogates is not to bar or eliminate human access or activity in the watershed or its riparian areas. It is the expectation, however, that the Implementation Plans will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, the Implementation Plans should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

DEQ intends to regularly review progress of the Implementation Plans. The plans, this overall WQMP, and the TMDLs are part of an adaptive management process. Modifications to the WQMP and the Implementation Plans are expected to occur on an annual or more frequent basis. Review of the TMDLs is expected to occur approximately five years after the final approval of the TMDLs, or whenever deemed necessary by DEQ.

Figure 4, gives the timeline for activities related to the WQMP and associated DMA Implementation Plans.

Figure 4: Water Quality Management Plan Timeline

Activity	2001	2002	2003	2004	2005	2006
DEQ Modification of General and Minor Permits						
DMA Development and Submittal of Implementation and Monitoring Plans						
DMA Implementation of Plans						
DEQ/DMA/Public Review of TMDL and WQMP						
DMA Submittal of Annual Reports	Sept. 30 of Each Year					

Figure 4. Water Quality Management Plan Timeline

CHAPTER 8 – REASONABLE ASSURANCE

This section of the WQMP is intended to provide reasonable assurance that the WQMP (along with the associated DMA-specific Implementation Plans) will be implemented and that the TMDL and associated allocations will be met.

There are several programs that are either already in place or will be put in place to help assure that this WQMP will be implemented. Many of these programs were developed in response to the phosphorus and ammonia TMDLs developed in 1988. Some of these are traditional regulatory programs such as specific requirements under NPDES discharge permits. Other programs address nonpoint sources under the auspices of state law (for forested and agricultural lands) and voluntary efforts.

POINT SOURCES

Reasonable assurance that implementation of the point source wasteload allocations will occur will be addressed through the revision, issuance or revision of NPDES and WPCF permits.

NPDES AND WPCF PERMIT PROGRAMS

The DEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. These are: the National Pollutant Discharge Elimination System (NPDES) permits for surface water discharge; and Water Pollution Control Facilities (WPCF) permits for onsite (land) disposal. The NPDES permit is also a Federal permit, which is required under the Clean Water Act for discharge of waste into waters of the United States. DEQ has been delegated authority to issue NPDES permits by the EPA. The WPCF permit is unique to the State of Oregon. As the permits are renewed, they will be revised to insure that all 303(d) related issues are addressed in the permit. These permit activities assure that elements of the TMDL WQMP involving urban and industrial pollution problems will be implemented.

For point sources, provisions to address the appropriate waste load allocations (WLAs) will be incorporated into NPDES permits when permits are renewed by DEQ, typically within 1 year after the EPA approves the TMDL. It is likely each point source will be given a reasonable time to upgrade, if necessary, to meet its new permit limits. A schedule for meeting the requirements will be incorporated into the permit. Adherence to permit conditions is required by State and Federal Law and DEQ has the responsibility to ensure compliance.

NONPOINT SOURCES

FORESTRY

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forest lands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe BMPs for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness. The Environmental Quality Commission, Board of Forestry, DEQ, and ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards. ODF provides on the ground field administration of the Forest Practices Act (FPA). For each administrative rule, guidance is provided to field administrators to insure proper, uniform and consistent application of the Statutes and Rules. The FPA requires penalties, both civil and criminal, for violation of Statutes and Rules. Additionally, whenever a violation occurs, the responsible party is obligated to repair the damage. For more information, refer to the Management Measures element of this Plan.

ODF and DEQ are involved in several statewide efforts to analyze the existing FPA measures and to better define the relationship between the TMDL load allocations and the FPA measures designed to protect water quality. Although the analysis and modeling in the TMDL demonstrate that increased levels of shade on many of the forested stream reaches in the watershed would decrease solar loading and potentially lower maximum daily stream temperatures, insufficient information exists to determine if specific FPA revisions will be necessary to meet the TMDL load allocations. The information in the TMDL, as well as other monitoring data, will be an important part of the body of information used in determining the adequacy of the FPA.

As the DMA for water quality management on nonfederal forest lands, the ODF is also working with the DEQ through a memorandum of understanding (MOU) signed in June of 1998. This MOU was designed to improve the coordination between the ODF and the DEQ in evaluating and proposing possible changes to the forest practice rules as part of the Total Maximum Daily Load process. The purpose of the MOU is also to guide coordination between the ODF and DEQ regarding water quality limited streams on the 303d list. An evaluation of rule adequacy will be conducted (also referred to as a "sufficiency analysis") through a water quality parameter by parameter analysis. This statewide demonstration of forest practices rule effectiveness in the protection of water quality will address the following specific parameters and will be conducted in the following order:

1) Temperature
2) Sediment and turbidity
3) Aquatic habitat modification
4) Bio-criteria
5) Other parameters

These sufficiency analyses will be reviewed by peers and other interested parties prior to final release. The analyses will be designed to provide background information and techniques for watershed-based assessments of BMP effectiveness and water quality assessments for watershed with forest and mixed land uses. Once the sufficiency analyses are completed, they will be used as a coarse screen for common elements applicable to each individual TMDL to determine if forest practices are contributing to water quality impairment within a given watershed and to support the adaptive management process. See Appendix E for a more detailed description of Oregon Department of Forestry TMDL-related activities.

Currently ODF does not feel that adequate data exists to make a collective determination on the sufficiency of the current FPA BMPs in meeting water quality standards within the Little River Watershed. This situation most closely resembles the scenario described under condition c of the ODF/DEQ MOU. Therefore, the current BMPs will remain as the forestry component of the TMDL. The draft versions of the statewide FPA sufficiency analyses for the various water quality parameters will be completed as noted above. The proposed Tualatin River TMDLs will be completed in the near future. The final report from the ad hoc committee advisory process was presented to the Board of Forestry in September 2000. Information from these efforts, along with other relevant information provided by the DEQ, will be considered in reaching a determination on whether the existing FPA BMPs meet water quality standards within the Little River Watershed.

AGRICULTURE

It is the Oregon Department of Agriculture's (ODA) statutory responsibility to develop agricultural water quality management (AWQM) area plans and enforce rules that address water quality issues on agricultural lands. The AWQM Act directs ODA to work with local farmers and ranchers to develop water quality management area plans for specific watersheds that have been identified as violating water quality standards and having agriculture water pollution contributions. The agriculture water quality management area plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct those problems. These water quality management plans are developed at a local level, reviewed by the State Board of Agriculture, and then adopted into the Oregon Administrative Rules. It is the intent that these plans focus on education, technical assistance, and flexibility in addressing agriculture water quality issues. These plans and rules will be developed or modified to achieve water quality standards and will address the load allocations identified in the TMDL. In those cases when an operator refuses to take action, the law allows ODA to take enforcement action. DEQ will work with ODA to ensure that rules and plans meet load allocations.

Recognizing the adopted rules need to be quantitatively evaluated in terms of load allocations in the TMDL and pursuant to the June 1998 Memorandum of Agreement between ODA and DEQ, the agencies will conduct a technical evaluation commencing in late 2001. The agencies will establish the relationship between the plan and its implementing rules and the load allocations in the TMDL to determine if the rules provide reasonable assurance that the TMDLs will be achieved. The AWQMA Local Advisory Committee (LAC) will be apprised and consulted during this evaluation. This adaptive management process provides for review of the AWQMA plan to determine if any changes are needed to the current AWQMA rules specific to the Umpqua Basin.

Appendix D includes the Agricultural Water Quality Management plan for the Umpqua Basin.

OREGON DEPARTMENT OF TRANSPORTATION

The Oregon Department of Transportation (ODOT) has been issued an NPDES MS4 waste discharge permit. Included with ODOT's application for the permit was a surface water management plan which has been approved by DEQ and which addresses the requirements of a TMDL allocation for pollutants associated with the ODOT system. Both ODOT and DEQ agree that the provisions of the permit and the surface water management plan will apply to ODOT's statewide system. This statewide approach for an ODOT TMDL watershed management plan addresses specific pollutants, but not specific watersheds. Instead, this plan demonstrates how ODOT will incorporate water quality protection into project development, construction, and operations and maintenance of the state and federal transportation system that is managed by ODOT, thereby meeting the elements of the National Pollutant Discharge Elimination System (NPDES) program, and the TMDL requirements.

The MS4 permit and the plan:

- Streamlines the evaluation and approval process for the watershed management plans
- Provides consistency to the ODOT highway management practices in all TMDL watersheds.
- Eliminates duplicative paperwork and staff time developing and participating in the numerous TMDL management plans.

Temperature and sediment are the primary concerns for pollutants associated with ODOT systems that impair the waters of the state. DEQ is still in the process of developing the TMDL water bodies and determining pollutant levels that limit their beneficial uses. As TMDL allocations are established by watershed, rather than by pollutants, ODOT is aware that individual watersheds may have pollutants that may require additional consideration as part of the ODOT watershed management plan. When these circumstances arise, ODOT will work with DEQ to incorporate these concerns into the statewide plan.

FEDERAL FOREST LANDS

All management activities on federal lands managed by the U. S. Forest Service (USFS) and the Bureau of Land Management must follow standards and guidelines (S&Gs) as listed in the respective Land Use and Management Plans (LRMPs), as amended, for the specific land management units.

NORTHWEST FOREST PLAN

In response to environmental concerns and litigation related to timber harvest and other operations on Federal Lands, the United States Forest Service (USFS) and the Bureau of Land Management (BLM) commissioned the Forest Ecosystem Management Assessment Team (FEMAT) to formulate and assess the consequences of management options. The assessment emphasizes producing management alternatives that comply with existing laws and maintaining the highest contribution of economic and social well being. The "backbone" of ecosystem management is recognized as constructing a network of late-successional forests and an interim and long-term scheme that protects aquatic and associated riparian habitats adequate to provide for *threatened species* and *at risk species*. Biological objectives of the Northwest Forest Plan include assuring adequate habitat on Federal lands to aid the "recovery" of late-successional forest habitat-associated species listed as threatened under the Endangered Species Act and preventing species from being listed under the Endangered Species Act.

URBAN AND RURAL SOURCES

Responsible participants for implementing DMA specific water quality management plans for urban and rural sources were identified in Chapter 5 of this Water Quality Management Plan. Upon approval of the Little River Watershed TMDLs, it is DEQ's expectation that identified, responsible participants will develop, submit to DEQ, and implement individual water quality management plans that will achieve the load allocations established by the TMDLs. These activities will be accomplished by the responsible participants in accordance with the Schedule in Chapter 7 of this Water Quality Management Plan. The DMA specific water quality management plans must address the following items:

1) Proposed management measures tied to attainment of the load allocations and/or established surrogates of the TMDLs, such as vegetative site potential for example.
2) Timeline for implementation.
3) Timeline for attainment of load allocations.
4) Identification of responsible participants demonstrating who is responsible for implementing the various measures.
5) Reasonable assurance of implementation.
6) Monitoring and evaluation, including identification of participants responsible for implementation of monitoring, and a plan and schedule for revision of implementation plan.
7) Public involvement.
8) Maintenance effort over time.

9) Discussion of cost and funding.
10) Citation of legal authority under which the implementation will be conducted.

Should any responsible participant fail to comply with their obligations under this WQMP, DEQ will take all necessary action to seek compliance. Such action will first include negotiation, but could evolve to issuance of Department or Commission Orders and other enforcement mechanisms.

THE OREGON PLAN

The Oregon Plan for Salmon and Watersheds represents a major effort, unique to Oregon, to improve watersheds and restore endangered fish species. The Oregon Plan is a major component of the demonstration of " reasonable assurance " that this TMDL WQMP will be implemented.

The Plan consists of four essential elements:

Coordinated Agency Programs:
Many state and federal agencies administer laws, policies, and management programs that have an impact on salmon and water quality. These agencies are responsible for fishery harvest management, production of hatchery fish, water quality, water quantity, and a wide variety of habitat protection, alteration, and restoration activities. Previously, agencies conducted business independently. Water quality and salmon suffered because they were affected by the actions of all the agencies, but no single agency was responsible for comprehensive, life-cycle management. Under the Oregon Plan, all government agencies that impact salmon are accountable for coordinated programs in a manner that is consistent with conservation and restoration efforts.

Community-Based Action:
Government, alone, cannot conserve and restore salmon across the landscape. The Oregon Plan recognizes that actions to conserve and restore salmon must be worked out by communities and landowners, with local knowledge of problems and ownership in solutions. Watershed councils, soil and water conservation districts, and other grassroots efforts are vehicles for getting the work done. Government programs will provide regulatory and technical support to these efforts, but local people will do the bulk of the work to conserve and restore watersheds. Education is a fundamental part of the community-based action. People must understand the needs of salmon in order to make informed decisions about how to make changes to their way of life that will accommodate clean water and the needs of fish.

Monitoring:
The monitoring program combines an annual appraisal of work accomplished and results achieved. Work plans will be used to determine whether agencies meet their goals as promised. Biological and physical sampling will be conducted to determine whether water quality and salmon habitats and populations respond as expected to conservation and restoration efforts.

Appropriate Corrective Measures:

The Oregon Plan includes an explicit process for learning from experience, discussing alternative approaches, and making changes to current programs. The Plan emphasizes improving compliance with existing laws rather than arbitrarily establishing new protective laws. Compliance will be achieved through a combination of education and prioritized enforcement of laws that are expected to yield the greatest benefits for salmon.

VOLUNTARY MEASURES

There are many voluntary, non-regulatory, watershed improvement programs (Actions) that are in place and are addressing water quality concerns in the Little River Watershed. Both technical expertise and partial funding are provided through these programs. Examples of activities promoted and accomplished through these programs include: planting of conifers, hardwoods, shrubs, grasses and forbs along streams; relocating legacy roads that may be detrimental to water quality; replacing problem culverts with adequately sized structures, and improvement/ maintenance of legacy roads known to cause water quality problems. These activities have been and are being implemented to improve watersheds and enhance water quality. Many of these efforts are helping resolve water quality related legacy issues.

LANDOWNER ASSISTANCE PROGRAMS

A variety of grants and incentive programs are available to landowners in the Little River Watershed. These incentive programs are aimed at improving the health of the watershed, particularly on private lands. They include technical and financial assistance, provided through a mix of state and federal funding. Local natural resource agencies administer this assistance, including the Oregon Department of Forestry, the Oregon Department of Fish and Wildlife, DEQ, and the National Resources Conservation Service.

Field staff from the administrative agencies provide technical assistance and advice to individual landowners, watershed councils, local governments, and organizations interested in enhancing the watershed. These services include on-site evaluations, technical project design, stewardship/conservation plans, and referrals for funding as appropriate. This assistance and funding is further assurance of implementation of the TMDL WQMP.

Financial assistance is provided through a mix of cost-share, tax credit, and grant funded incentive programs designed to improve on-the-ground watershed conditions. Some of these programs, due to source of funds, have specific qualifying factors and priorities. Cost share programs include the Forestry Incentive Program (FIP), Stewardship Incentive Program (SIP), Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentive Program (WHIP).

CHAPTER 9 – MONITORING AND EVALUATION

Monitoring and evaluation has two basic components: 1. Implementation of DMA specific water quality management plans identified in this document; and 2. Physical, chemical and biological parameters for water quality and specific management measures. This information will provide information on progress being made toward achieving TMDL allocations and achieving water quality standards and to use as we evaluate progress as described under Adaptive Management in Chapter 1: Introduction.

The information generated by each of the agencies/entities gathering data in the Little River Watershed will be pooled and used to determine whether management actions are having the desired effects or if changes in management actions and/or TMDLs are needed. This detailed evaluation will typically occur on a 5-year cycle. If progress is not occurring, then the appropriate management agency will be contacted with a request for action.

The objectives of this monitoring effort are to demonstrate long-term recovery, better understand natural variability, track implementation of projects and BMPs, and track effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the "reasonable assurance of implementation" for the Little River Watershed TMDL WQMP

This WQMP and the DMA-specific Implementation Plans will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. The mechanism for tracking DMA implementation efforts will be annual reports to be submitted to DEQ.

CHAPTER 10 – PUBLIC INVOLVEMENT

To be successful at improving water quality a TMDL WQMP must include a process to involve interested and affected stakeholders in both the development and the implementation of the plan. The DEQ has held two public meetings in the Little River Watershed to inform residents of the progress of TMDL development and receive input. This document, together with the TMDL, was included in the public notice regarding the TMDL and there will be a public meeting as well as a public hearing regarding the TMDLs. Future Little River Watershed TMDL public involvement efforts will focus specifically on riparian restoration projects and rural residential, agricultural and forestry activities. DMA-specific public involvement efforts will be detailed within the Implementation Plans included in the appendices.

CHAPTER 11 – COSTS AND FUNDING

Designated Management Agencies will be expected to provide a fiscal analysis of the resources needed to develop, execute and maintain the programs described in their Implementation Plans.

The purpose of this element is to describe estimated costs and demonstrate there is sufficient funding available to begin implementation of the WQMP. Another purpose is to identify potential future funding sources for project implementation. There are many natural resource enhancement efforts and projects occurring in the watershed which are relevant to the goals of the plan. These efforts, in addition to proposed future actions are described in the Management Measurers element of this Plan.

POTENTIAL SOURCES OF PROJECT FUNDING

Funding is essential to implementing projects associated with this WQMP. There are many sources of local, state, and federal funds. The following is a partial list of assistance programs available in the Little River Watershed.

Program	Agency/Source
Oregon Plan for Salmon and Watersheds	OWEB
Environmental Quality Incentives Program	USDA-NRCS
Wetland Reserve Program	USDA-NRCS
Conservation Reserve Enhancement Program	USDA-NRCS
Stewardship Incentive Program	ODF
Access and Habitat Program	ODFW
Partners for Wildlife Program	USDI-FSA
Conservation Implementation Grants	ODA
Water Projects	WRD
Nonpoint Source Water Quality Control (EPA 319)	DEQ-EPA
Riparian Protection/Enhancement	COE
Oregon Community Foundation	OCF

Grant funds are available for improvement projects on a competitive basis. Field agency personnel assist landowners in identifying, designing, and submitting eligible projects for these grant funds. For private landowners, the recipient and administrator of these grants is generally the local Soil and Water Conservation District. Grant fund sources include:

Oregon Watershed Enhancement Board (OWEB) which funds watershed improvement projects with state money. This is an important piece in the implementation of Oregon's Salmon Plan. Current and past projects have included road relocation/closure/improvement projects, in-stream structure work, riparian fencing and revegetation, off stream water developments, and other management practices.

Individual grant sources for special projects have included Forest Health money available through the State and Private arm of the USDA Forest Service.

CHAPTER 12 – CITATION TO LEGAL AUTHORITIES

CLEAN WATER ACT SECTION 303(D)

Section 303(d) of the 1972 federal Clean Water Act as amended requires states to develop a list of rivers, streams and lakes that cannot meet water quality standards without application of additional pollution controls beyond the existing requirements on industrial sources and sewage treatment plants. Waters that need this additional help are referred to as “water quality limited” (WQL). Water quality limited waterbodies must be identified by the Environmental Protection Agency (EPA) or by a state agency which has been delegated this responsibility by EPA. In Oregon, this responsibility rests with the DEQ. The DEQ updates the list of water quality limited waters every two years. The list is referred to as the 303(d) list. Section 303 of the Clean Water Act further requires that Total Maximum Daily Loads (TMDLs) be developed for all waters on the 303(d) list. A TMDL defines the amount of pollution that can be present in the waterbody without causing water quality standards to be violated. An WQMP is developed to describe a strategy for reducing water pollution to the level of the load allocations and waste load allocations prescribed in the TMDL, which is designed to restore the water quality and result in compliance with the water quality standards. In this way, the designated beneficial uses of the water will be protected for all citizens.

The Oregon Department of Environmental Quality is authorized by law to prevent and abate water pollution within the State of Oregon pursuant to the following statute:

ORS 468B.020 **Prevention of pollution**

(1) Pollution of any of the waters of the state is declared to be not a reasonable or natural use of such waters and to be contrary to the public policy of the State or Oregon, as set forth in ORS 468B.015.

(2) In order to carry out the public policy set forth in ORS 468B.015, the department shall take such action as is necessary for the prevention of new pollution and the abatement of existing pollution by:

- (a) Fostering and encouraging the cooperation of the people, industry, cities and counties, in order to prevent, control and reduce pollution of the waters of the state; and
- (b) Requiring the use of all available and reasonable methods necessary to achieve the purposes of ORS 468B.015 and to conform to the standards of water quality and purity established under ORS 468B.048.

NPDES AND WPCF PERMIT PROGRAMS

The DEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. These are: the National Pollution Discharge

Elimination System (NPDES) permits for waste discharge; and Water Pollution Control Facilities (WPCF) permits for waste disposal. The NPDES permit is also a Federal permit and is required under the Clean Water Act. The WPCF permit is a state program. As permits are renewed they will be revised to insure that all 303(d) related issues are addressed in the permit.

OREGON ADMINISTRATIVE RULES

The following Oregon Administrative Rules provide numeric and narrative criteria for parameters of concern in the Little River Watershed:

TMDL Parameter: Temperature
Applicable Rules: OAR 340-041-0285 (2)(b)(A)
OAR 340-041-0026 (3)(a)(D)
OAR 340-041-0006 (54) and (55)
OAR 340-041-0120 (11)

TMDL Parameter: pH
Applicable Rules: OAR 340-041-0285 (2)(d)(A)
OAR 340-041-0282

TMDL Parameter: Sedimentation
Applicable Rules: OAR 340-041-0285 (2)(j)

OREGON FOREST PRACTICES ACT

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forest lands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describes BMPs for forest operations. The Environmental Quality Commission (EQC), Board of Forestry, DEQ and ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards.

ODF and DEQ statutes and rules also include provisions for adaptive management that provide for revisions to FPA practices where necessary to meet water quality standards. These provisions are described in ORS 527.710, ORS 527.765, ORS 183.310, OAR 340-041-0026, OAR 629-635-110, and OAR 340-041-0120.

SENATE BILL 1010

The Oregon Department of Agriculture has primary responsibility for control of pollution from agriculture sources. This is accomplished through the Agriculture Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010 adopted by the Oregon State Legislature in 1993. The AWQM Act directs the ODA to work with local farmers and ranchers to develop water quality management plans for specific watersheds that have been identified as violating water quality standards and have agriculture water pollution contributions. The agriculture water quality management plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct the problems.

(ODOT and Federal Land Managers)

LOCAL ORDINANCES

Within the Implementation Plans in the appendices, the DMAs are expected to describe their specific legal authorities to carry out the management measures they choose to meet the TMDL allocations. Legal authority to enforce the provisions of a City's NPDES permit would be a specific example of legal authority to carry out management measures.

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Little River
Stream Temperature Model

DEQ Western Region

January 30, 2001

DEQ

State of Oregon
Department of Environmental Quality

Survey Purpose

Field measured data (collected on 9/14/95) was used to calibrate a stream temperature model, *Heat Source 6.0*. Current monitoring data sets strive to collect data during the time of maximum solar loading (plus or minus two weeks from August 1st). The Little River data set was collected several years before Heat Source 6.0 was available, and had been optimized to collect data during the summer's lowest stream flows. Two simulations, one using the peak solar loading of August 1st and another using mid-September solar loading, showed essentially no difference in the resulting stream temperature profile. Therefore, calibrating to the mid-September time frame should introduce little, if any, additional error to the analysis.

The model uses field measurements and model-derived parameters as inputs to simulate how stream temperatures respond to unique conditions within the watershed. Once the model parameters have been balanced so that the simulation accurately describes the conditions measured in the field (the calibration step), reasonable and obtainable "future conditions" are entered into the model. The model recalculates the amount of energy reaching the stream and estimates stream temperatures based on those future condition(s) simulated. Equilibrium conditions are calculated for each of the 432 segments that make up the Little River model (segments are 100 meters long).

Two additional reaches, a short section of Jim Creek and the lower 12 miles of Cavitt Creek, were also instrumented. See Map 1 for the extent of the Little River watershed that was modeled. Both reaches wound up with only one upstream one downstream temperature logger data set (some instruments were stolen during the summer). Because of the lack of middle data sets to aid calibration, these simulations will not be presented in detail. However, the simulated stream temperatures at the downstream location (the tributary mouth) **were** used as inputs for the Little River future condition simulations (See Figures 19a and 19b).

Two future conditions for Little River were modeled: the "System Potential" condition and the "Current Management Potential" condition, described below.

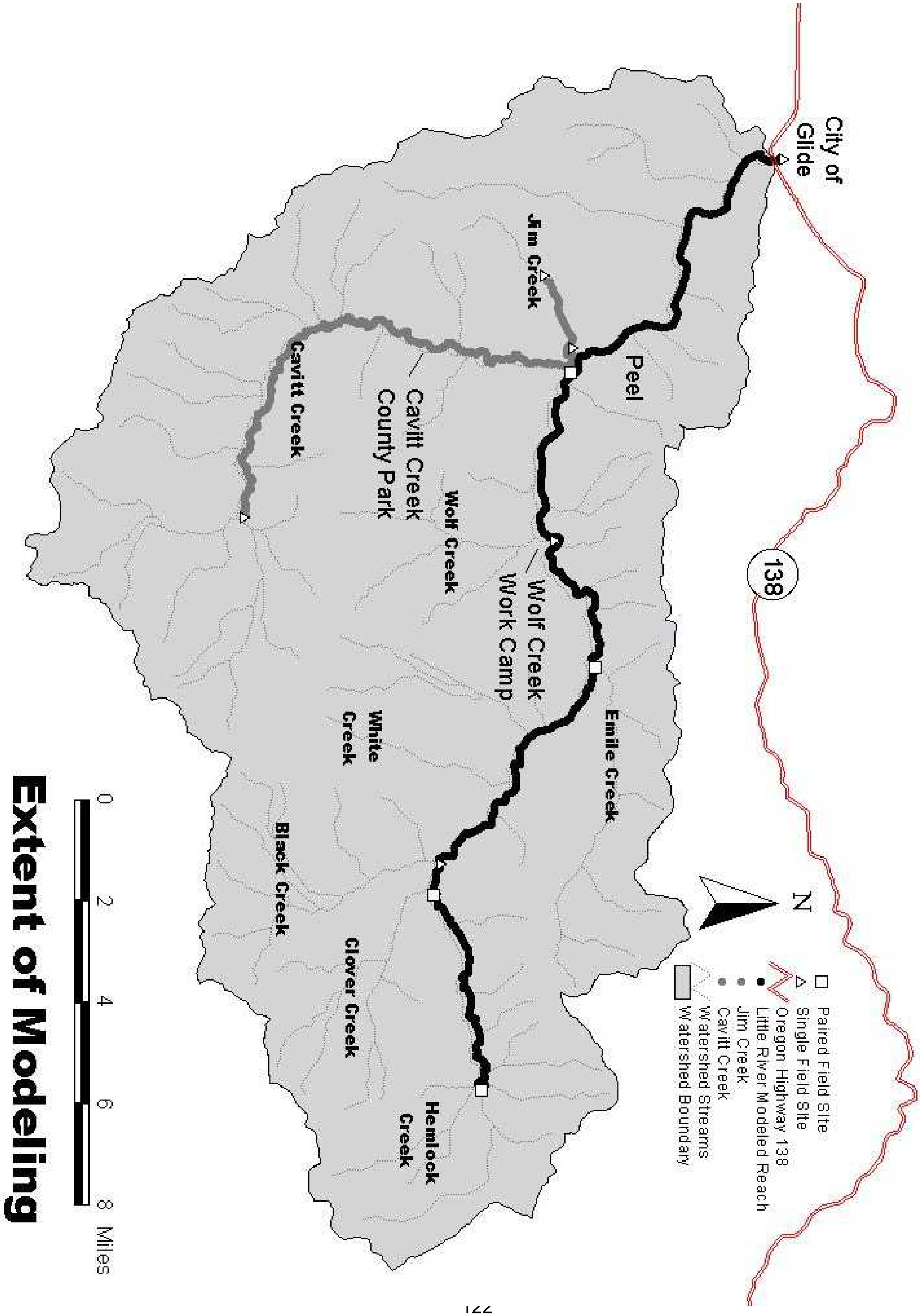
System Potential

This condition assumes a watershed where all shade producing vegetation has grown to its maximum height and density for these soils, rainfall and ecoregion (simulation assumes 140' trees and 76% shade density). The width of the shade buffer is wider than that required to achieve maximum shade values. System potential does not assume any changes in vegetation due to human activities. This "System Potential" simulation also assumes that all channel parameters and flow profiles were unchanged from the calibration condition.

Current Management Potential

Simulation of this scenario is an attempt to understand how our present management options will affect temperature if implemented. This simulation assumes that trees will grow just as high and dense as in the shade potential simulation, but that any shade buffer width is constrained by present zoning setbacks and special management zones (Oregon Forest Practices Act, Northwest Forest Plan). The actual widths used in the simulation are outlined in the Shade Width section. Channel parameters and flow profiles were also unchanged from those used in the calibration process.

Data used in the modeling were of high quality, and the model calibrated easily with the data, so there is confidence in the model simulation results. But, like any model that attempts to "look into the future," there is likely to be a disparity between what is predicted and what will actually come to pass. Our understanding of the processes that determine stream temperature are imperfect, and any predictions using them are similarly imperfect. Any resulting simulation of the future is less a blueprint with survey point accuracy than a roadmap that identifies only the most obvious landmarks. Roadmaps, however, are useful for planning a journey and navigating to a destination. While only the broadest suggestions of possible management strategies are suggested by the model, they should point us in the right direction.


City of Glide
Jim Creek
Peel
Cavitt Creek
Cavitt Creek County Park
Wolf Creek
Wolf Creek Work Camp
138
Emile Creek
White Creek
Black Creek
Clover Creek
Hemlock Creek
N
Paired Field Site
Single Field Site
Oregon Highway 138
Little River Modeled Reach
Jim Creek
Cavitt Creek
Watershed Streams
Watershed Boundary
0
2
4
6
8 Miles
Extent of Modeling

Temperature Sets

Hourly instantaneous stream temperatures were taken throughout the summer at six locations within the Little River mainstem and six tributary locations (see Map 1 for locations) using calibrated and audited logging devices. The term "paired site" means that there was a logger placed both in the mainstem upstream of the tributary and near the tributary mouth Each logger data set was reviewed, and it was determined that the data from 9/14/95 was most suitable to a basin-wide Heat Source simulation. Each data set, if required, was thinned to 24 hourly observations for the day.

Stream Discharge Measurements

Flow measurements were taken at all 12 mainstem and tributary sites within two days of September 14th. Measurements were via hand-held current meters. Measurement transects were chosen in areas with wadeable cross-sections and good stream velocities. Each transect consisted of a minimum of 10 individual measurements.

Stream/Shade Conditions

Riparian characteristics relating to shade quality and quantity were measured from aerial photography, digital imagery and on site field measurements. The shading values so calculated were: shade height, shade belt width, shade density and shade overhang. Values assumed for the two "future condition" simulations were based on forest characteristics appropriate to this ecoregion, soil class, species composition and expected tree density. Channel wetted width was also measured via field observations.

Model Inputs

Elevation/Gradient

Elevations were obtained from digital elevation information (Digital Elevation Model - DEM - type data). The elevation of the upstream and downstream point of each reach segments was derived. These elevations were related to the elapsed reach lengths so that elevation and gradient profiles could be calculated. See Figures 1 & 2.

Figure 1

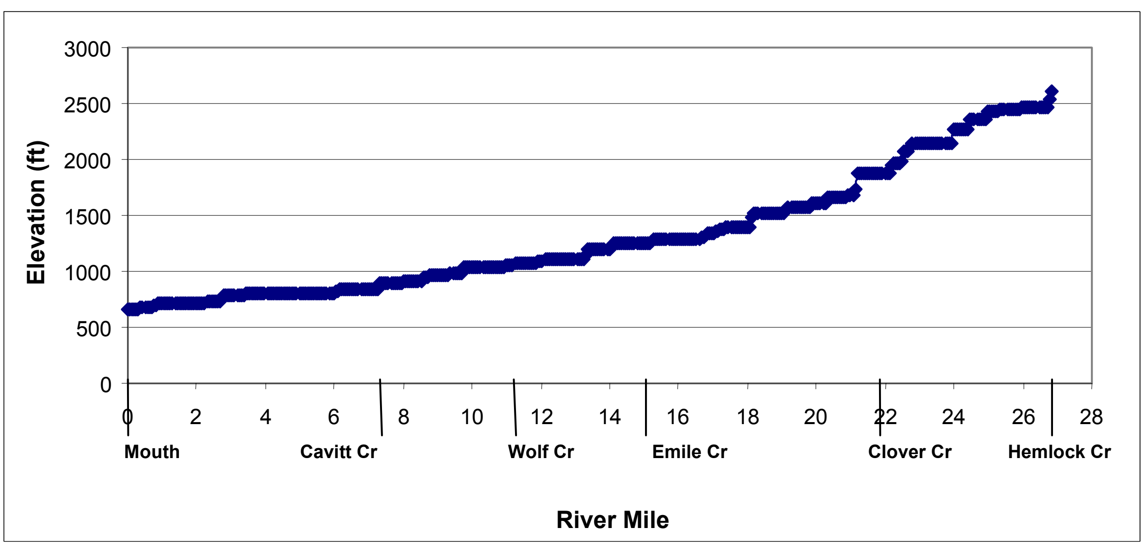
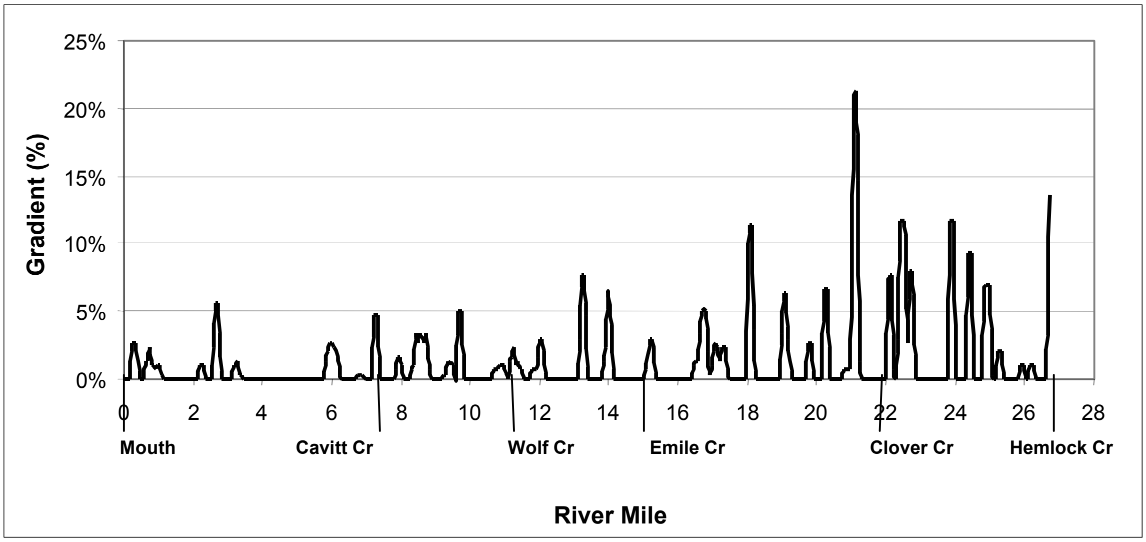


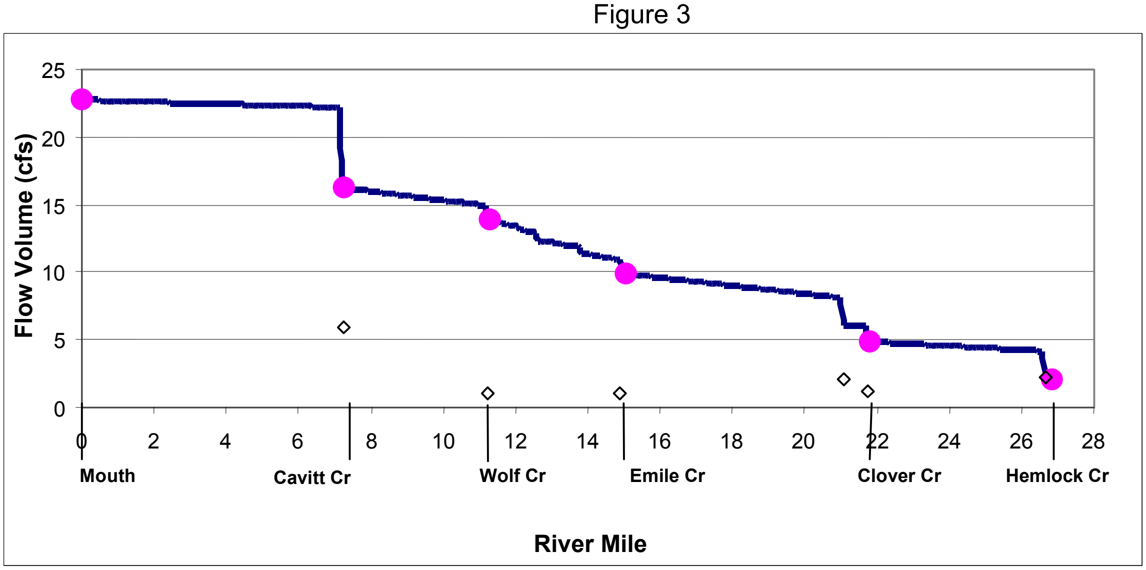
Figure 2



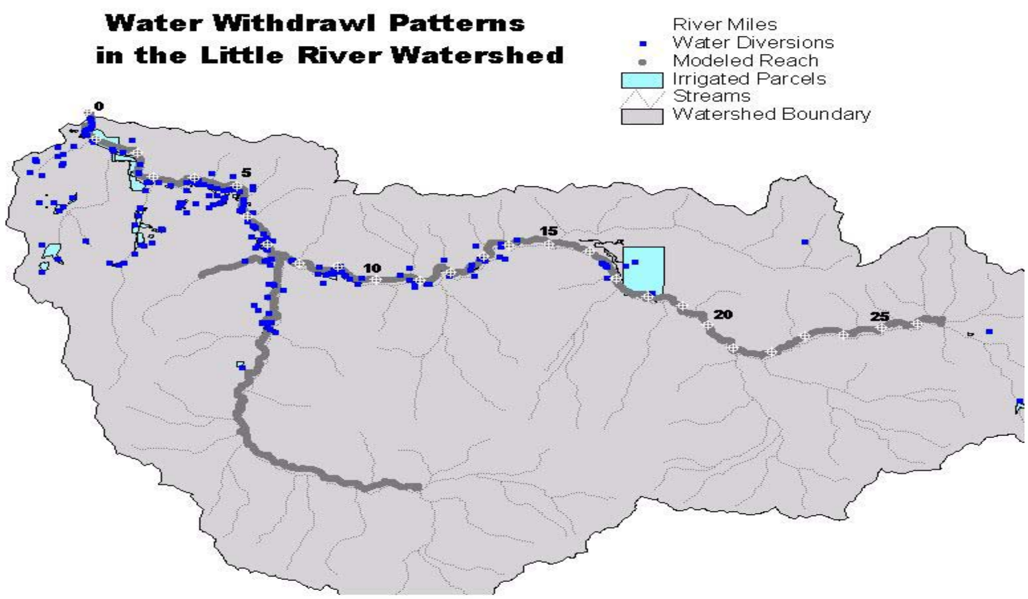
Flow Volume

Flow was measured on the mainstem at the sites shown in Figure 3 as solid dots. Flow measured at tributary mouths is shown as open diamonds. Flows downstream of each tributary are calculated by adding the mainstem flow to the tributary flow. Intervening flow was extrapolated so that a complete flow profile could be constructed.

Figure 3

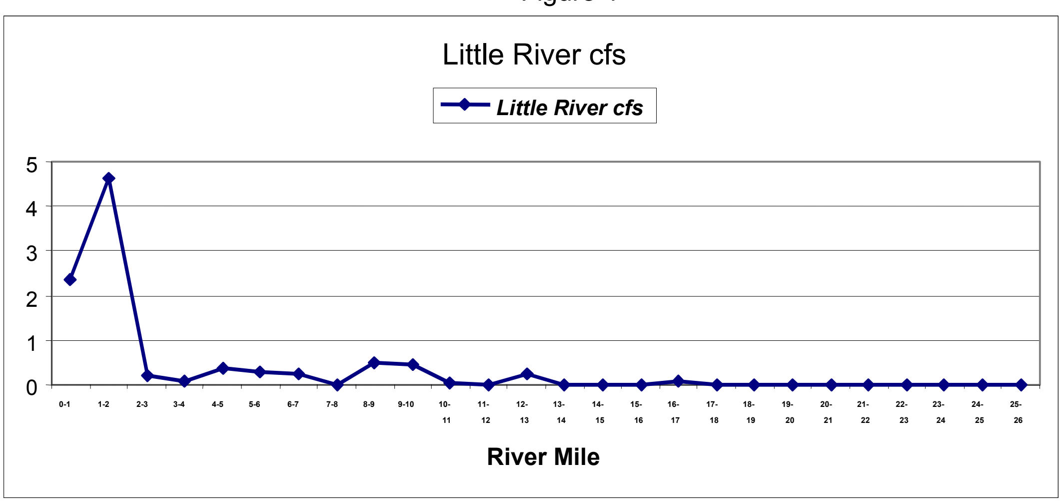


Significant flow in the Little River Watershed is allocated for irrigation and domestic use. The modeled section of the main stem of Little River currently has legal water diversions of up to 9.5 cfs in flow. The tributaries along this reach potentially divert an additional 18.5 cfs. Not all of these points withdraw their full allocation all the time. These points of diversion along the modeled reach are identified in the map shown below. No attempt was made to identify which diversions were active during the week that flows in Little River were measured. Figure 4 shows how much flow is potentially diverted between each mile of river. This gives an idea



as to which sections of the modeled reach might be most prone to fluctuations in flow during the calibration phase and in the future condition predictions.

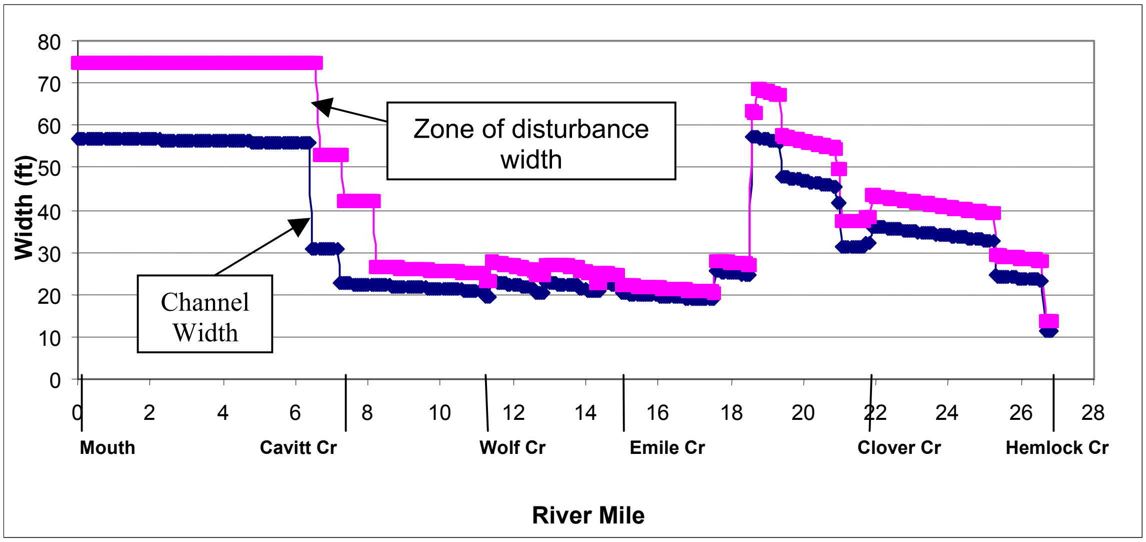
Figure 4



Channel Wetted Width / Zone of Disturbance Width

Channel width (upper line) was measured in the field or scaled off of conventional or digital photos. The zone of disturbance width (lower line) was scaled from aerial photos. The zone of disturbance is defined as the distance between the shade-producing areas on either bank. Figure 5 shows the width profiles used in the model.

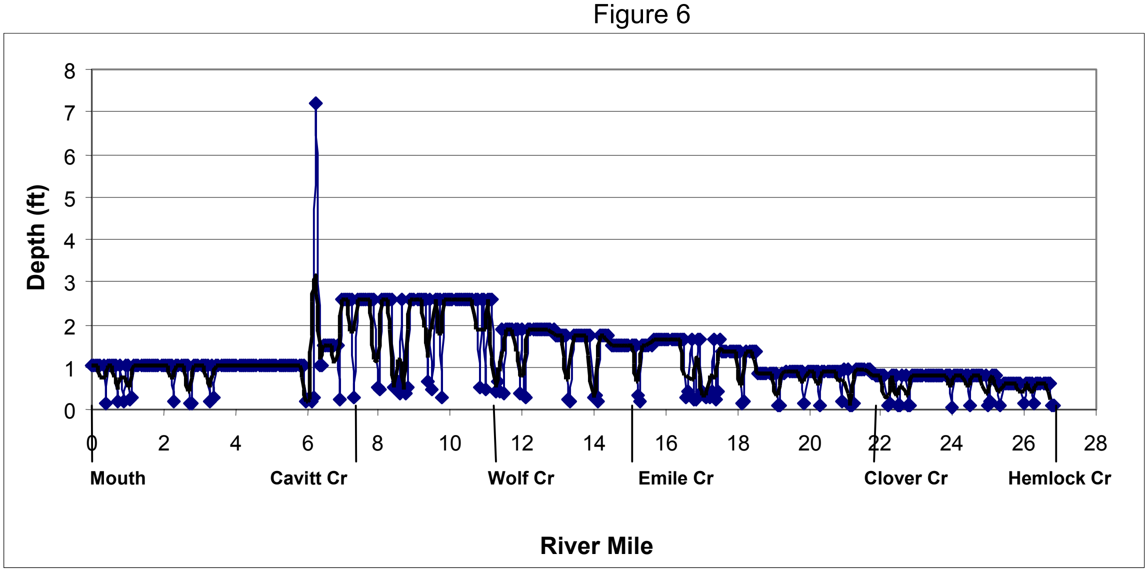
Figure 5



Average Depth

Average depth for each segment was calculated from the flow volume and wetted width values used for that segment. Figure 6 shows the average depth profile used in the model. The spike seen near river mile 6 corresponds to a mainstem impoundment at Peel.

Figure 6



Flow Velocity

Average velocity for each segment was calculated from the channel geometry, segment slope and Manning's "n" used for that segment. The velocity profile is shown in Figure 7. Figure 8 shows the assumed time of travel along the modeled reach using the flow velocities seen in Figure 7.

Figure 7

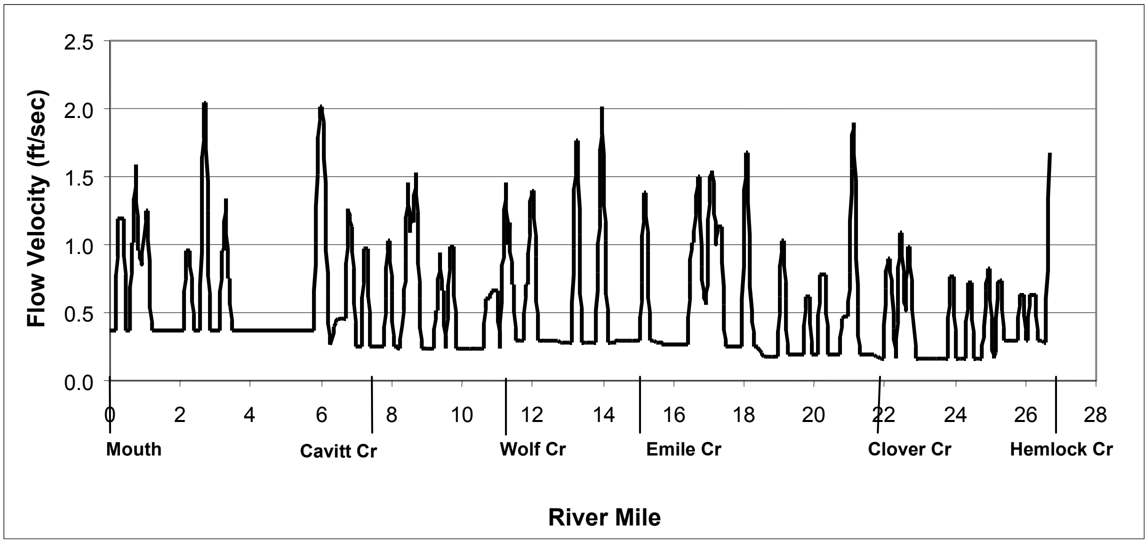
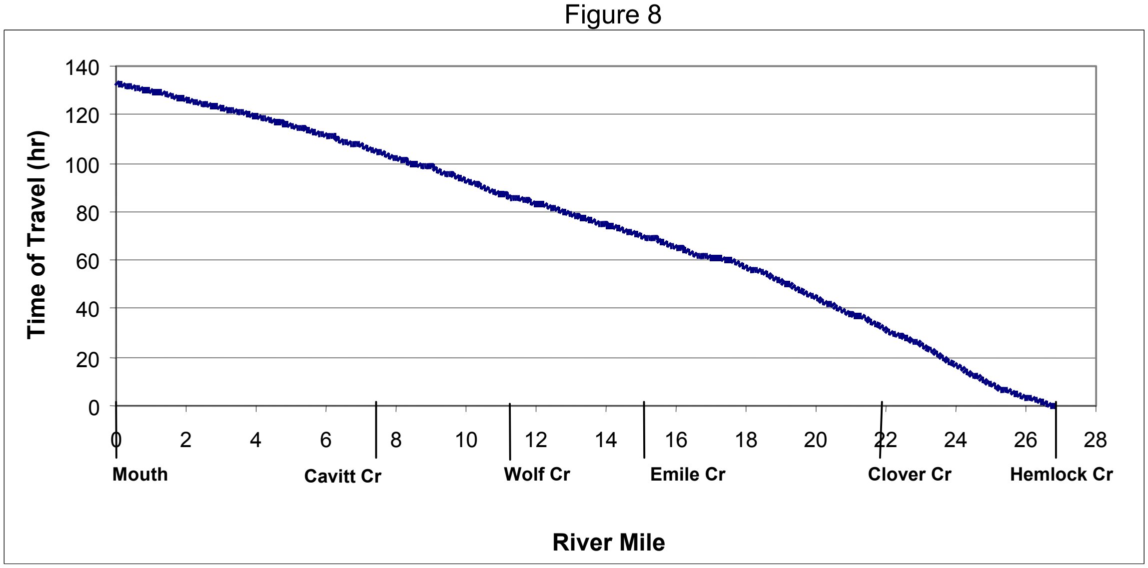


Figure 8



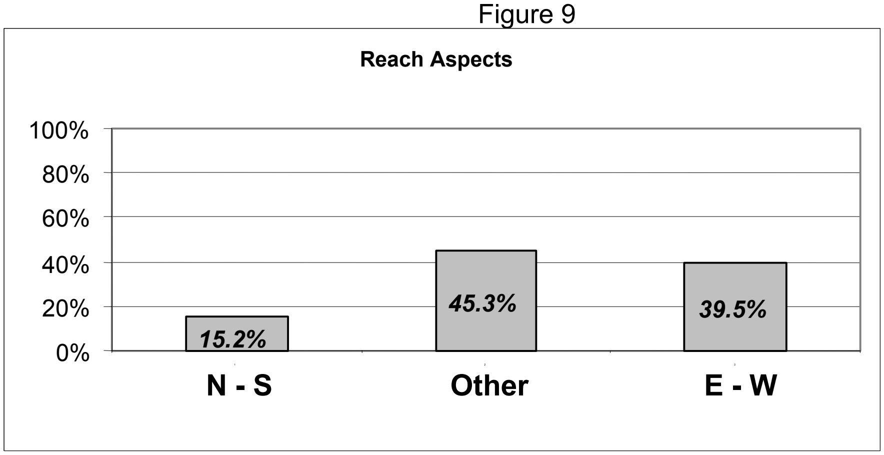
Channel Substrate

Channel substrate larger that cobble size can absorb solar energy and re-release it during the night. The Little River mainstem channel above Wolf Creek was assumed to have a 10% cobble or larger composition. Little River below Wolf Creek was assumed to have 50% cobble or larger composition.

Stream Aspect

Figure 9 shows the relative amount of the Little River main stem study reach headed in these general directions. Aspect is important because North – South streams are less influenced by riparian shading as a means of temperature control while East – West streams are greatly affected by riparian shade. Almost 85% of the stream miles along the Little River should have an average or better than average response to riparian shade for temperature control.

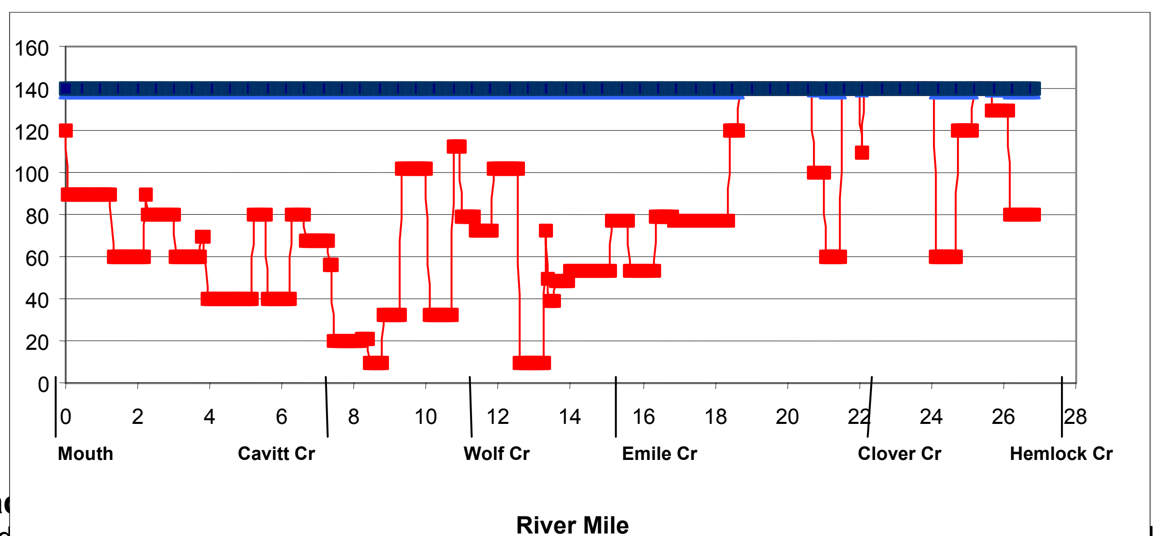
Figure 9



Shade Height

Shade height is one of three shade parameters that is assumed to change for the future condition simulations. The calibration condition for shade height, based on field measurements, is shown in Figure 10 as the lower (red) line. The assumed future condition for system potential is shown as the upper (blue) line. The shade height used for the current management potential condition (black) is essentially the same as for the system potential case.

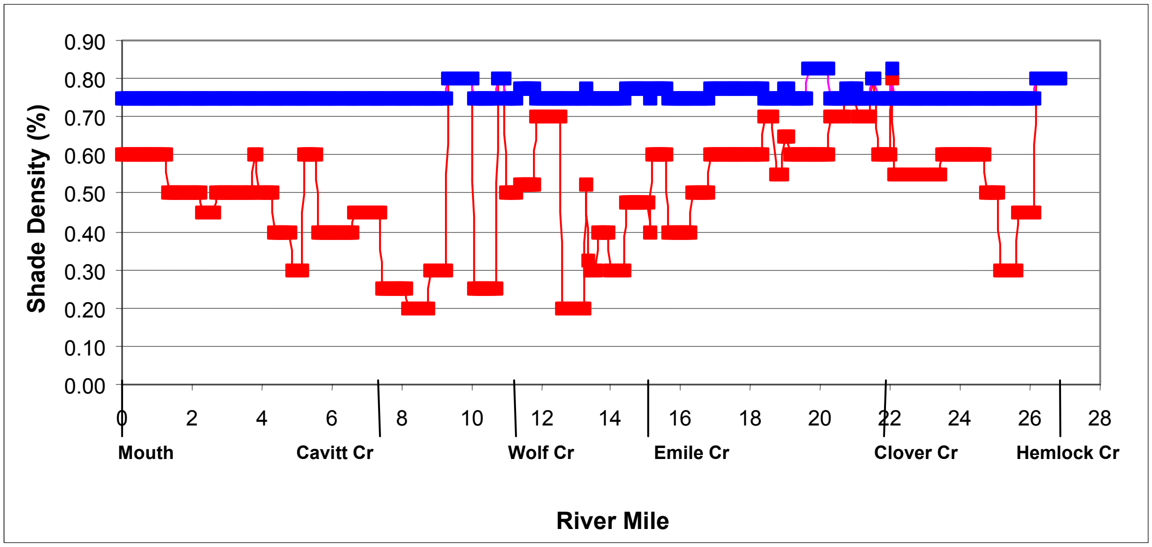
Figure 10



Shad

Shad ld measured shade density as it exists today. The future shade densities, used in both the system potential and current management potential simulations are assumed to be uniform (top line in figure 11, centered at the 75% value). In some cases, the existing shade density is already greater than 75%. In these cases, the present value is used for both future simulations. Many future shade densities will likely be higher than 75%, so choosing this value will add a margin of safety to the future condition projections.

Figure 11



Shade Width

The current width of the shade producing zone was measured form aerial photographs. This average width is shown as the lower (red) line in figure 12. The assumed width for the current management potential condition is shown in figure 12 as the middle (blue) line. These widths were derived from the expected setbacks called for in present zoning classifications and special management areas. See Tables 1-3 for a tabulation of the widths used. Map 2 shows where these designations applied. The shade width used for the system potential simulation (top black line in figure 12) was 300'. This width was chosen because it is beyond the width needed to provide full shading. The actual width needed to provide full shade in any particular segment will depend on local conditions.

Figure 12

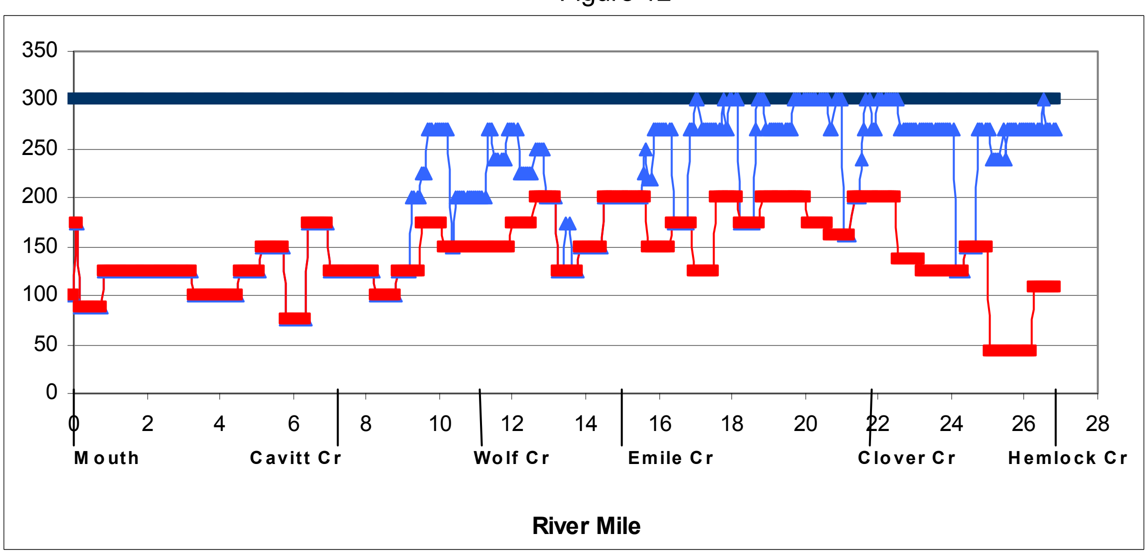


Table 1

Expected Future Shade Belt Widths Used in the Little River Model

Management Designation	Jim Creek	Cavitt Creek	Little River
Farm Forest	-	-	50'
Farm Grazing	-	-	50'
Forest Practices Act	70'	100'	100'
Northwest Forest Plan	-	300'	300'
Recreation Areas	-	250'	250'
Rural Residential	50'	50'	50'
City of Glide	-	-	25'

Notes:
Land Use classification derived from Douglas County and State of Oregon zoning maps.
All shade widths were reduced by 60' when a road was within 300' of the stream.
The present shaded width was used if greater than the expected future width.

Table 2

Total Stream Miles in each Land Use Designation

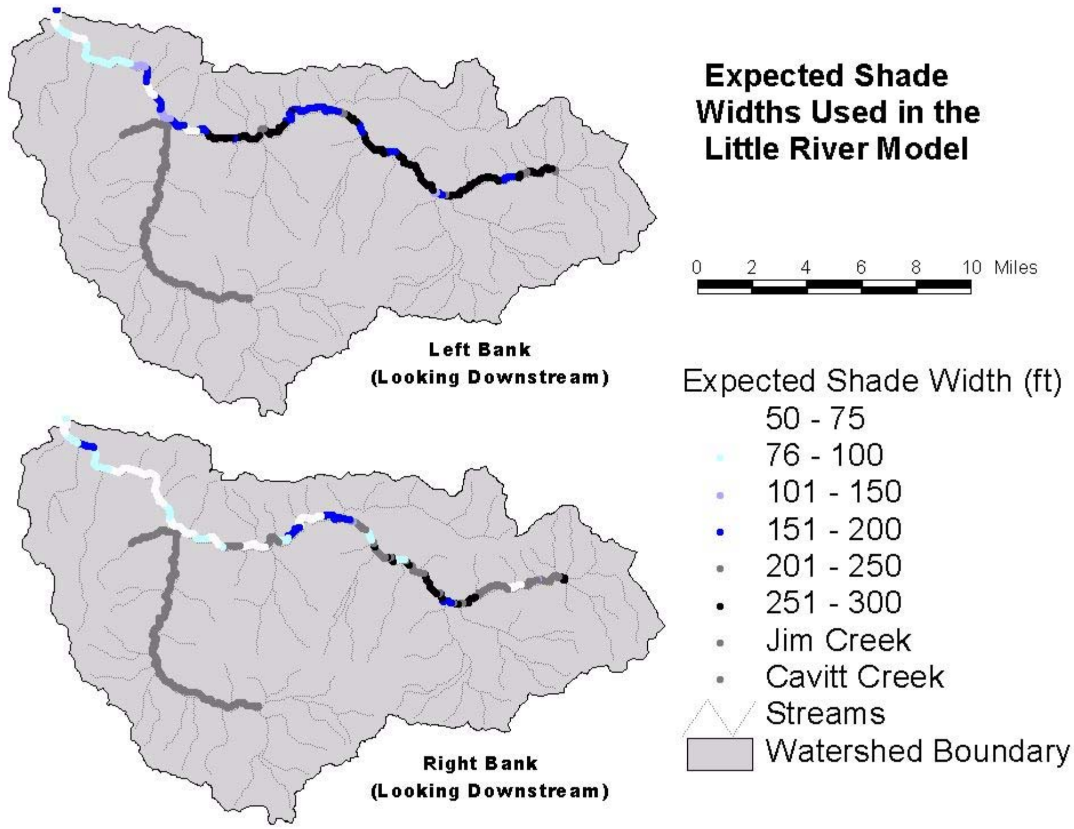
Management Designation	Jim Creek	Cavitt Creek	Little River
Farm Forest	-	-	0.9
Farm Grazing	-	-	3.2
Forest Practices Act	1.7	7.2	3.4
Northwest Forest Plan	-	1.1	12.1
Recreation Areas	-	0.7	0.2
Rural Residential	0.2	3.1	7.0
City of Glide	-	-	0.2
Total Miles Modeled	1.9	12.1	27.0

Table 3

Total Stream Miles Affected by Roads

Jim Creek	Cavitt Creek	Little River
0.0	2.2	16.6

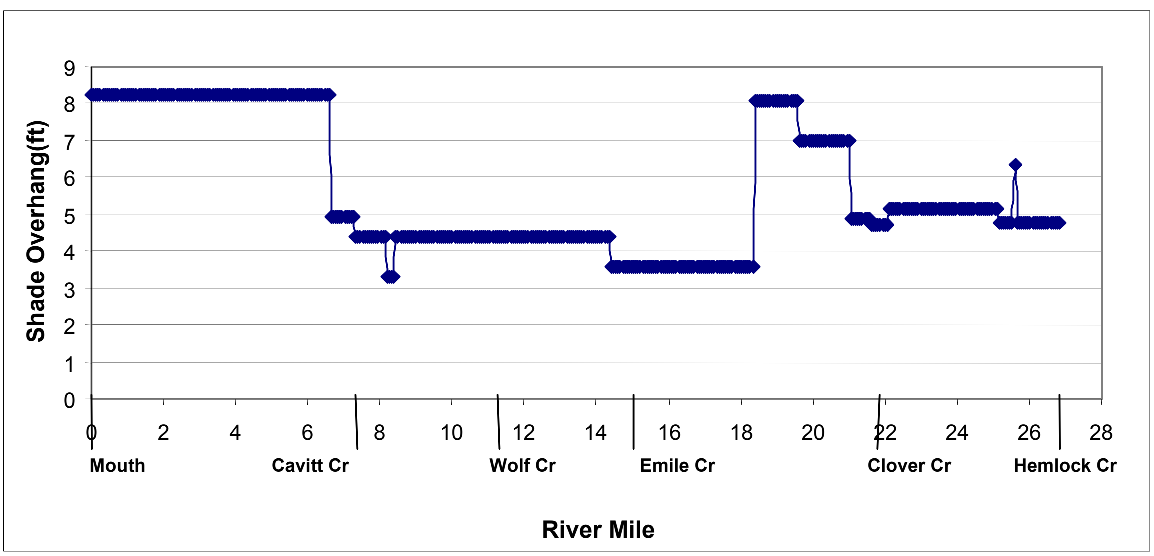
Map 2



Shade Overhang

The shade overhang profile used in the calibration conditions was used unchanged in both of the future condition simulations. Expected increases in shade overhang that are not used in the simulation result in an additional margin of safety in the analysis.

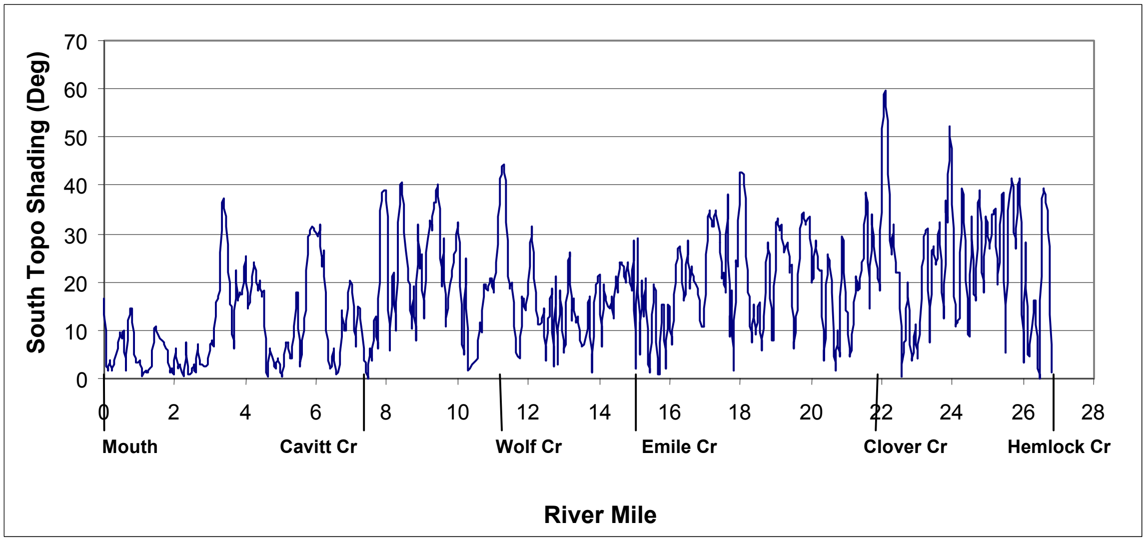
Figure 13



Topographic Shading

Topographic shading is defined as the shading provided to the stream by ridgelines or hills. It is extremely localized and unique for each system. Southern shading can result in an appreciable lowering of solar energy during the day. East/West shading effectively shortens the amount of daylight hours by delaying local sunrise or hastening local sunset. Figure 14 shows that many parts of Little River get a generous amount of topographic shading to the south.

Figure 14



Model Input Data Summary

Below is a summary of the model parameters used, how they were derived, and if that parameter was changed between the calibration and the future condition simulations. Parameters in italic type are those used for model calibration.

Data Class	Parameter	Method (measured/calculated)	Source	Future Condition Different from Calibration
Stream	Elevation	Measured	DEM Data	No
	Gradient	Calculated	GIS Utility	No
	Topographic Shade	Calculated	GIS Utility	No
	Stream Reach Aspect	Calculated	GIS Utility	No
Flow	Volume	Measured	Field Measurement	No
	Velocity	Measured/Calculated	*Model calculated To field data*	No
	Depth	Measured/Calculated	*Model calculated To field data*	No
Channel	Zone-of-Disturbance Width	Measured	Digital Photos	No
	Wetted Width	Measured/Calculated	Model calculated To field data	No
	Channel Substrate	Measured	Field Measurement	No

Shade	Height	Measured	Field Measurement	**Yes**
	Width	Measured	Field Measurement	Yes
	Density	Measured	Field Measurement	**Yes**
	Overhang	Measured	Field Measurement	No
Stream Temperature	Main Stem	Measured	Field Measurement	---
	Tributaries	Measured	Field Measurement	Yes
Weather	Humidity	Measured	Field Measurement	No
	Wind Speed	Measured	Field Measurement	Yes
	Air Temperature	Measured	Field Measurement	No

Model Calibration

All models require some calibration to make the computer simulation match the observed data. For this series of Heat Source simulations, the only parameters that changed during the calibration process were Manning's “n”, average channel width and average channel depth. The average width/depth values, although not measured in each of the 432 segments, were compared to a handful of actual measurements (usually taken during flow volume measurements). Care was taken so that model-calculated values did not divert significantly from the field-observed values.

Any data obtained from field measurements or scaled from photos were used as recorded. Adjustments to the three calibration parameters ceased when the simulation output matched the observed field data. None of the calibration parameters were changed during the simulation of future conditions.

Most models are calibrated to one set of conditions. A unique feature of the Heat Source model is that it allows calibration simulations to be compared directly to observed stream temperature logged during an entire 24 hour day. This allows calibration to not only daily minimum and maximum values, but also the ability to fit modeled heating and cooling rates to observed data. For this study, the main-stem of Little River had six data loggers where simulated vs. observed data sets could be compared. A summary of how well the modeled set matched the field measured set is shown below. Each logger summary is based on 24 data pairs (one pair for each hour throughout the day).

Logger Location	**Approximate River Mile**	**"r Squared" Value**	**Standard Deviation (Deg)**	**Standard Error (Deg)**	
Upstream Hemlock	26.8	1.000	0.07	0.08	
Upstream Clover	21.8	0.844	4.62	0.33	
Upstream Emile	25.7	0.752	1.62	0.65	
Upstream Wolf	11.3	0.876	0.95	0.27	
Upstream Cavitt	7.3	0.842	1.51	0.45	
Mouth	0.0	0.758	1.00	0.72	
	Avg	0.845	1.628		Deg C
	Avg		2.931	0.750	Deg F

Reach-specific difficulty was experienced in the early stages of model calibration. Predicted temperatures were warmer than the instream logger observations, especially in the stretch between Emile and Wolf Creeks. In order to cool the predicted temperatures down, groundwater inputs to Little River were assumed within this section. Field investigation during the summer of 2000 found numerous groundwater sources entering Little River throughout this reach, supporting the assumption.

Model Output

Solar Flux

Figure 15 shows the total daily solar flux loading by river mile. The upper (black) line shows the total amount of solar energy available to the Little River system. The dips in available energy near river miles 22 and 24 are due to local topographic shading. The next line down (thick red) is the daily solar flux available for stream heating under current conditions. The next two lines down are projected loading expected for the two future condition simulations. The lowest line (thick dark blue) corresponds to the system potential condition. The thin line (light blue) between the system potential and current conditions is the projected solar loading for the current management potential condition. Figure 16 uses the same symbols and colors as figure 15, however the total solar flux data is excluded. This allows an expansion of scale for closer examination of the current/expected solar flux simulations.

Figure 15

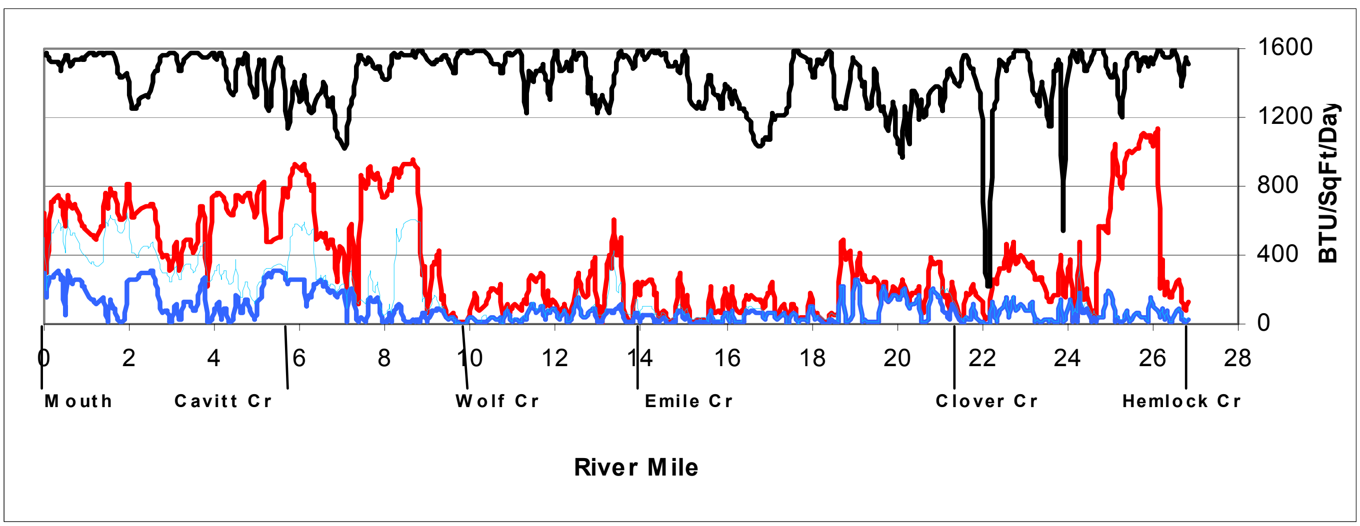


Figure 16

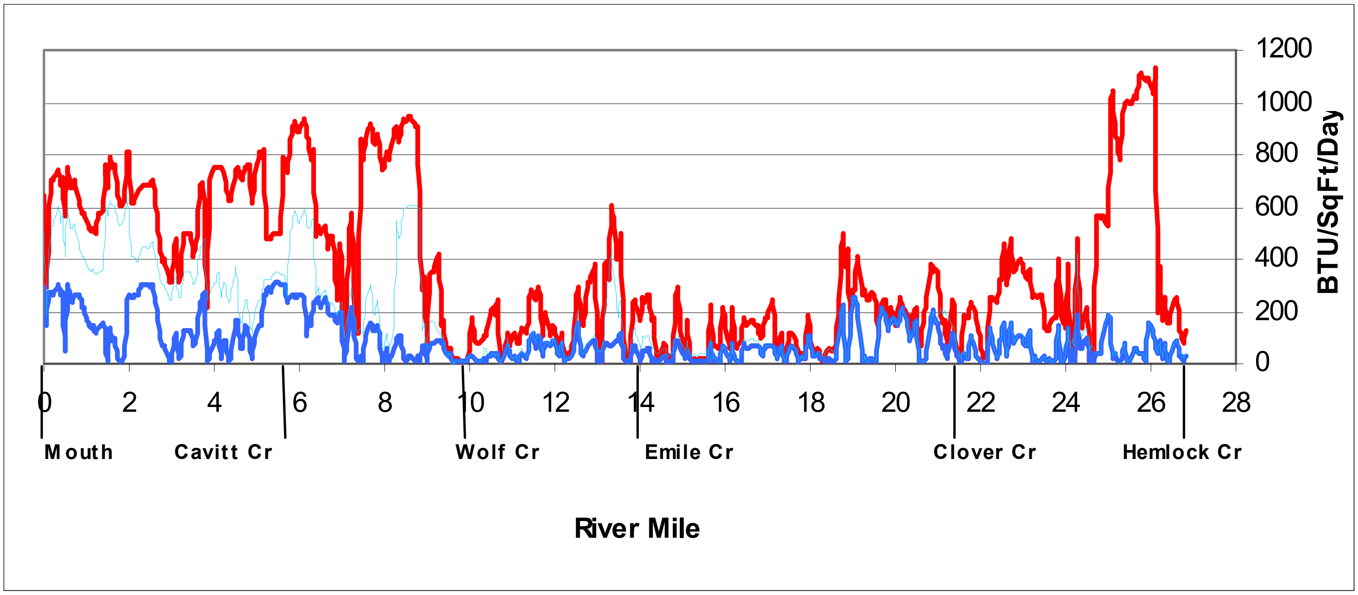


Figure 17a and 17b show the solar flux information displayed as percentile plots. The colors are the same as in figures 15 and 16.

Figure 17a

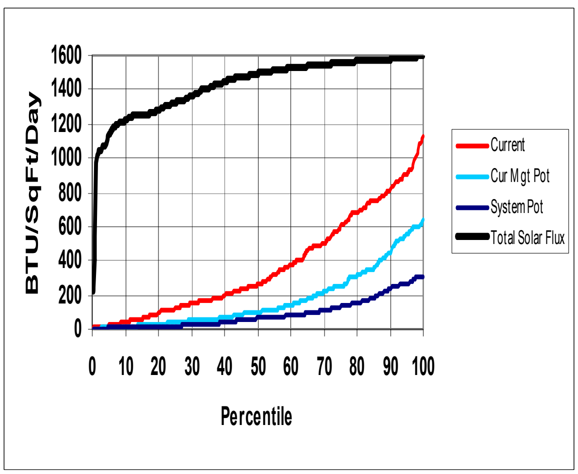
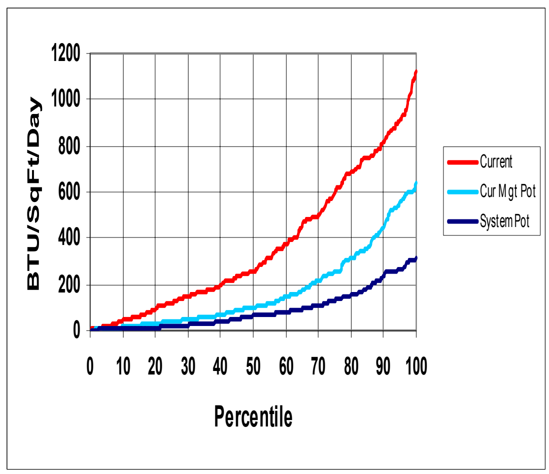


Figure 17b



Effective Shading in the Riparian Zone

Effective shading is defined as the amount of available solar flux intercepted before reaching the stream. A situation which allows 200 BTU/SqFt/Day to enter the stream when the available solar flux is 1500 BTU/SqFt/Day would be calculated as (all units are BTU/SqFt/Day):

Total Available Energy	1500
Energy Blocked	1500-200 =1300
Effective Shade Percentage	(1300/1500)*100 = 86.7%

Figure 18 and Map 3 shows the amount of effective shading provided to the stream by riparian vegetation in the present and two future conditions. Present conditions provide a distance-weighted average of 74.5% shade to the main stem (lower thick red line), while future conditions should provide 88% shade in the current management potential condition (middle dashed line) and almost 94% in the system potential condition (upper thick blue line). Figure 19 is the percentile plot of the % Effective shading data.

Figure 18

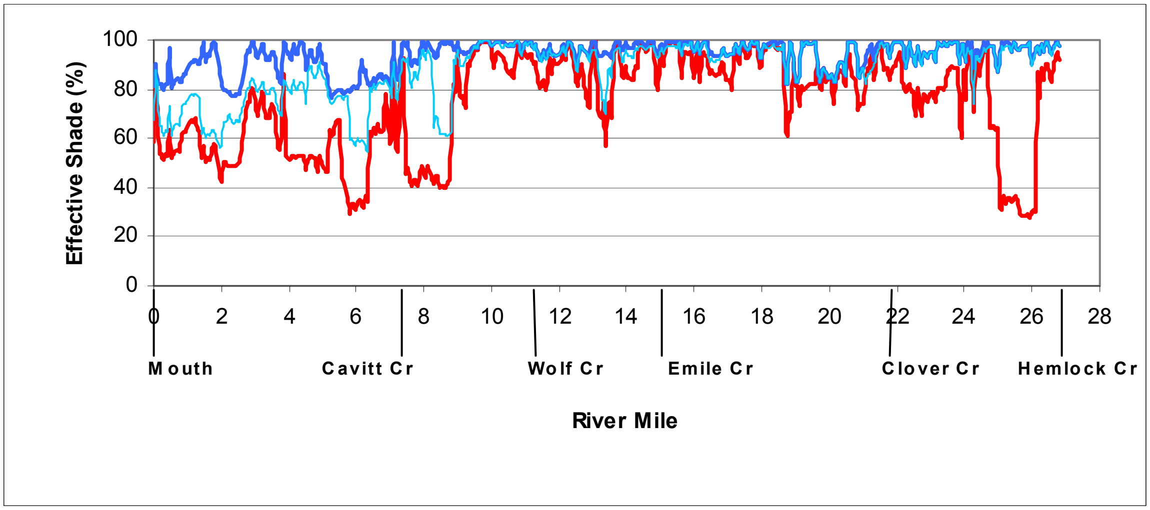
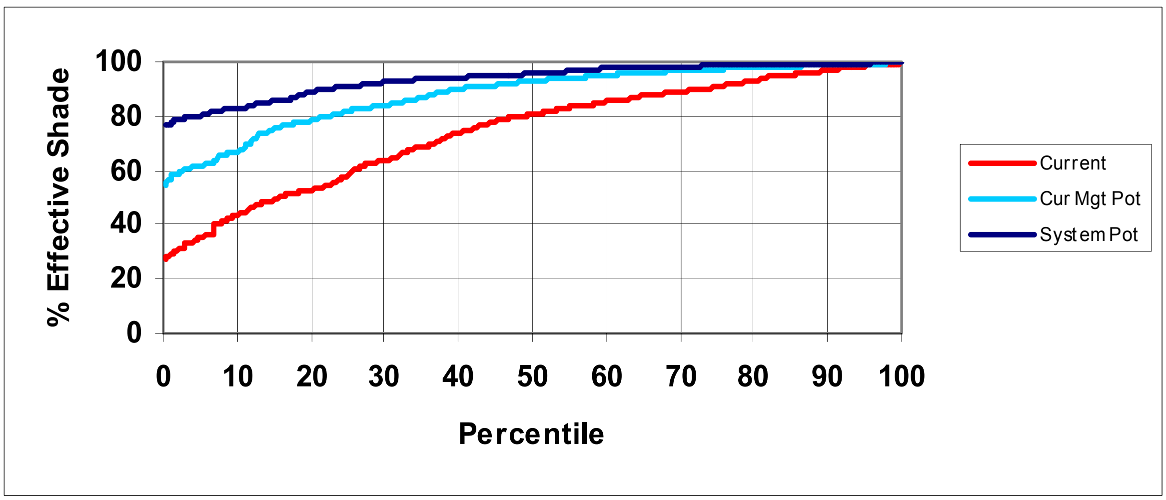


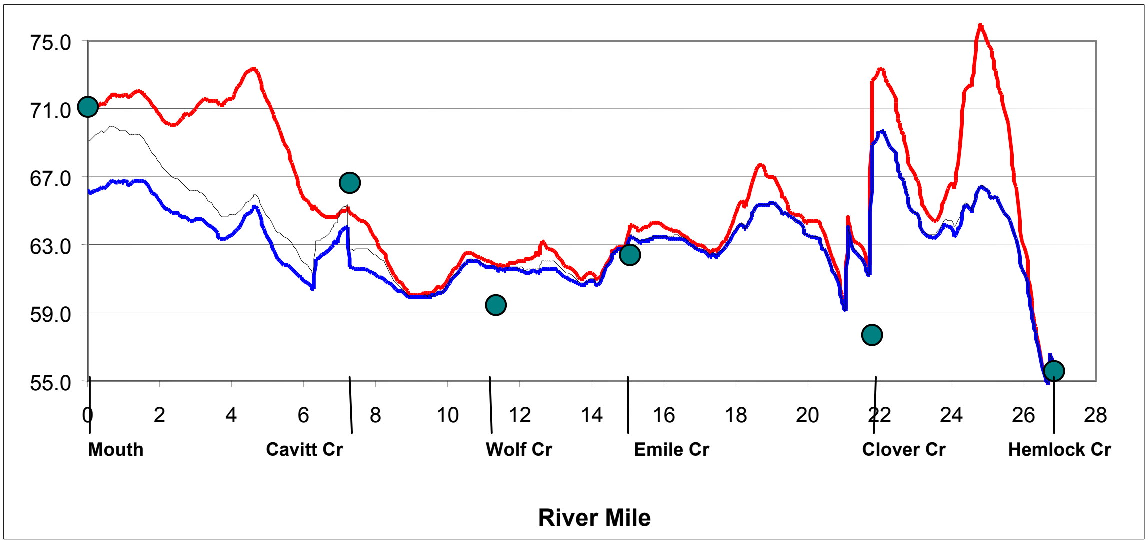
Figure 19



Stream Temperature

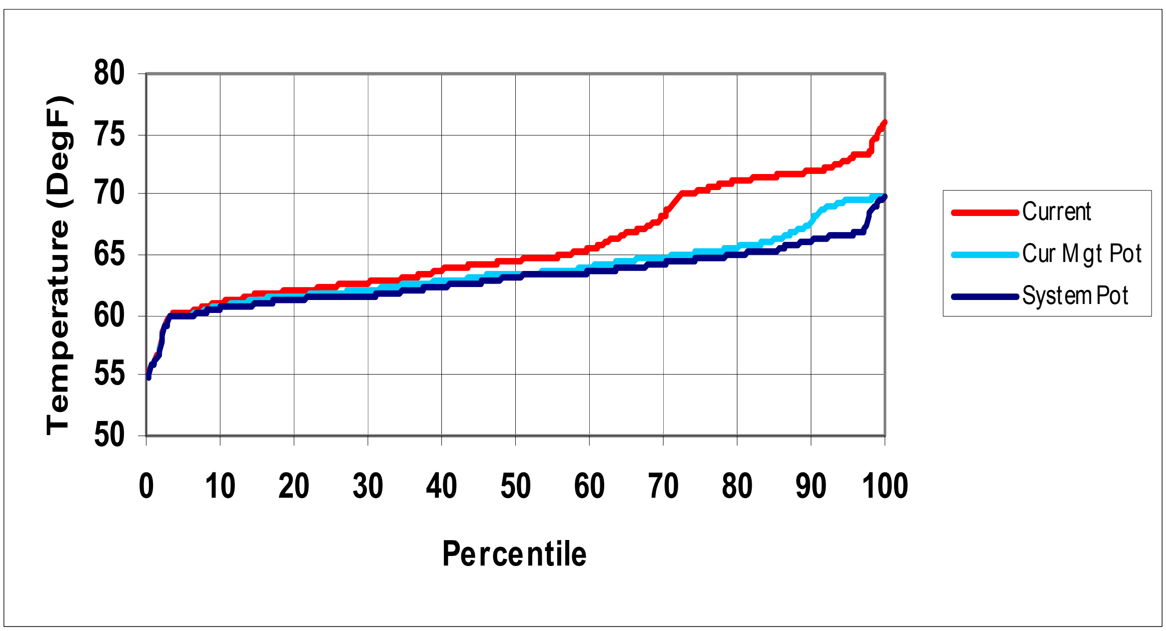
Figure 20 and Map 4 shows current stream temperature conditions and two projected stream temperature profiles. The open circles in Figure 19 are the corresponding same-day 4:00 PM temperatures recorded by the six data loggers deployed in the main stem. The r-squared value of actual vs. simulated temperatures for these six locations (4:00 PM temperatures only, n = 6) was 0.797. The two expected future stream temperature profiles are based on the assumed future conditions. All temperature profiles show stream temperatures **at 4:00 PM in the afternoon in mid-September** The difference between the lines shows potential reduction in stream temperature if the assumed future conditions are achieved.

Figure 20



In Figure 20, the top thick (red) line shows the present temperature profile, the bottom thick (blue) line shows the system potential temperature and the middle think (black) line shows the current management potential temperature profile. The model simulation for each future condition did not assume any additional cooling to any tributary other than Jim and Cavitt Creek. **Any additional cooling in any of the tributary sub-watersheds would result in additional cooling in the main stem of Little River.** The percentile plot of temperature data is shown in Figure 21.

Figure 21



The next two graphs (Figures 22a and 22b) show the temperature data broken into 5 different temperature–range intervals. These intervals are roughly comparable to probable success of salmonid survival/reproduction. At the extremes, temperatures below 55 degrees F. are optimal for reproduction, temperatures above 72 degrees are lethal to immature fish. These graphs show the same information, only displayed in different formats. Again, these temperatures would be expected **at 4:00 PM in mid-September.**

Figure 22a

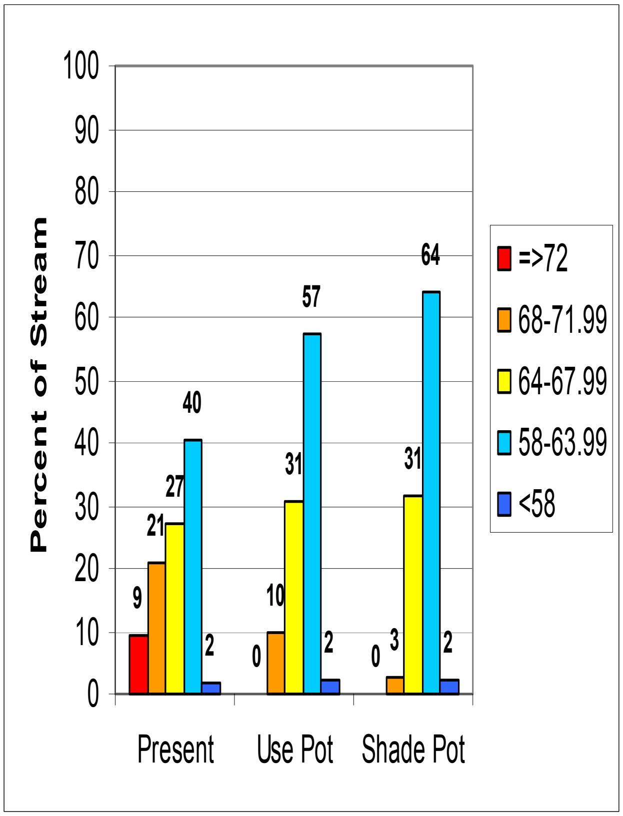
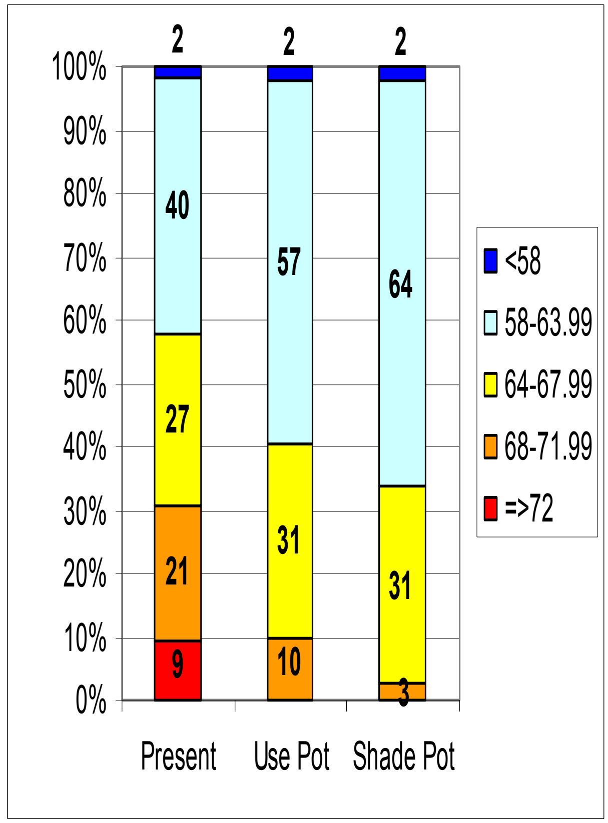
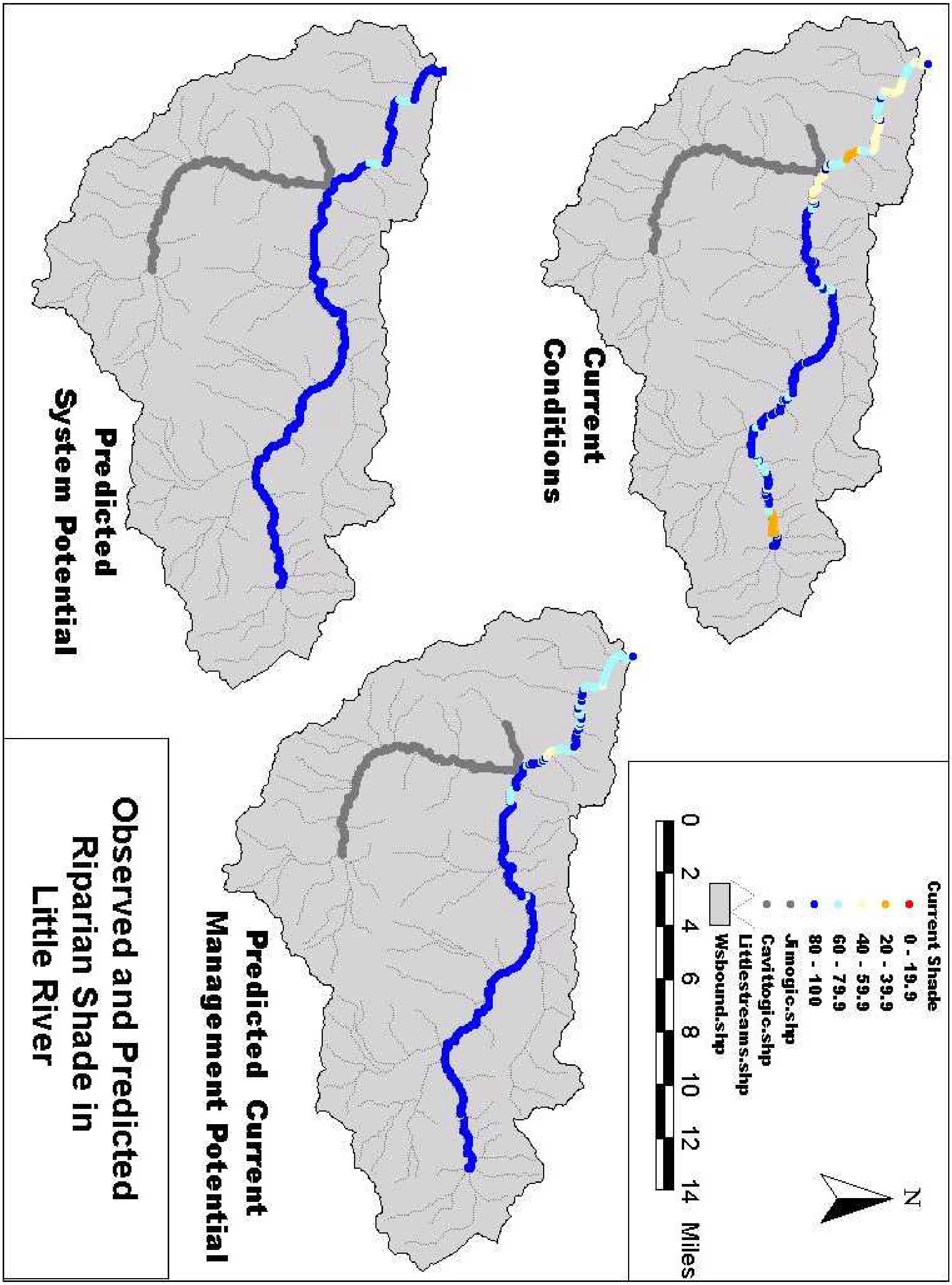


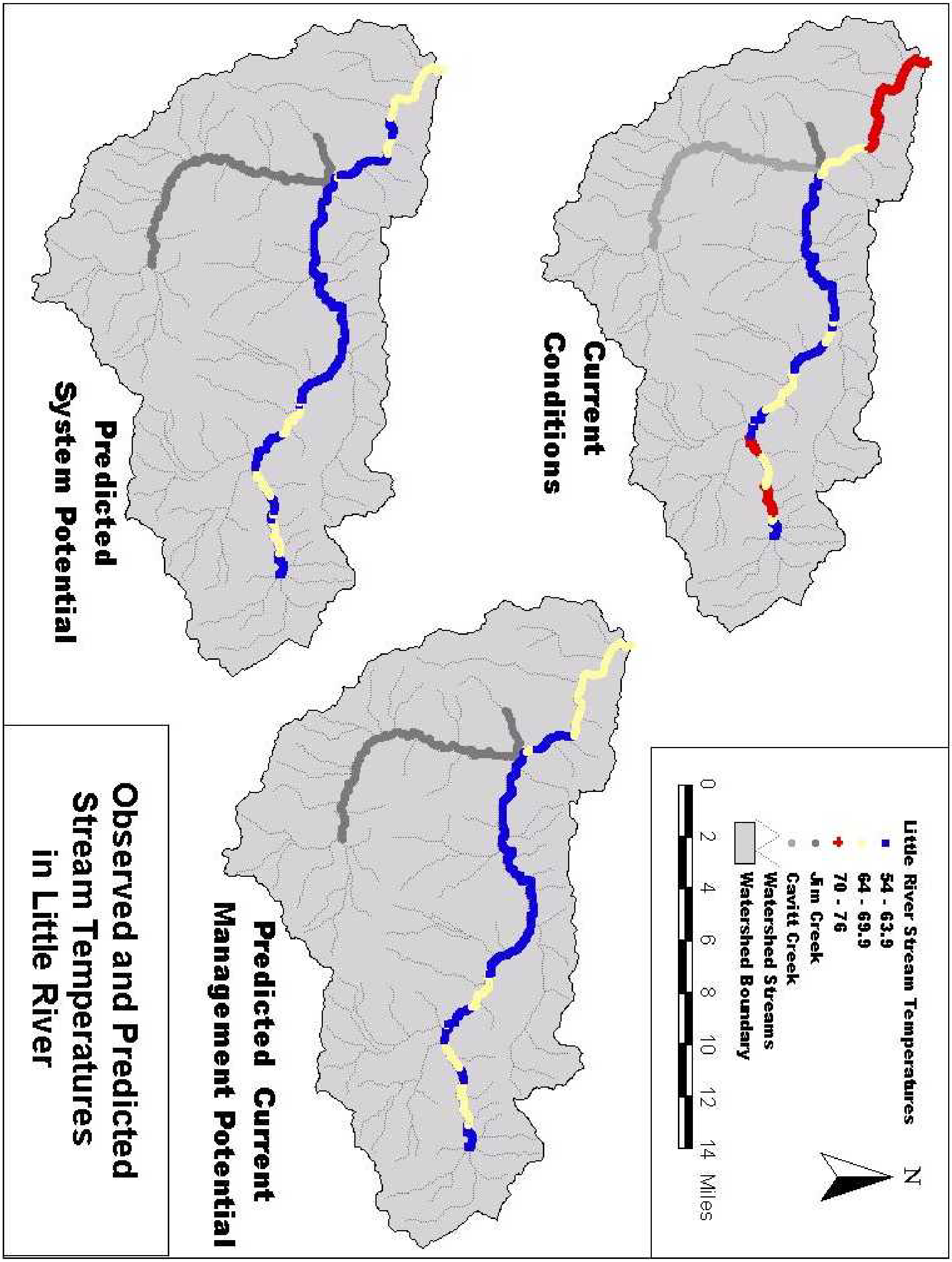
Figure 22b



Map 3


Observed and Predicted
Riparian Shade in
Little River
Current
Conditions
Predicted
System Potential
Predicted Current
Management Potential
Current Shade
0 - 19.9
20 - 39.9
40 - 59.9
60 - 79.9
80 - 100
Jinogic.shp
Cavittogic.shp
Littlestreams.shp
Wsbound.shp
0 2 4 6 8 10 12 14 Miles
N

Map 4


Observed and Predicted
Stream Temperatures
in Little River
Current
Conditions
Predicted
System Potential
Predicted Current
Management Potential
Little River Stream Temperatures
54 - 63.9
64 - 69.9
70 - 76
Jim Creek
Cavitt Creek
Watershed Streams
Watershed Boundary
0 2 4 6 8 10 12 14 Miles
N

The Cumulative Effects of Tributary Cooling

It is not possible to calibrate and project future conditions in the bulk of tributaries within Little River. The field data and modeling time required is prohibitive. It was possible to put instruments into Jim and Cavitt Creeks so that future conditions could be simulated. These expected future temperatures were used as inputs for the mainstem model so that the cumulative effects of tributary cooling on the mainstem could be examined. These projected temperatures are shown in Figures 23a and 23b.

Figure 23a

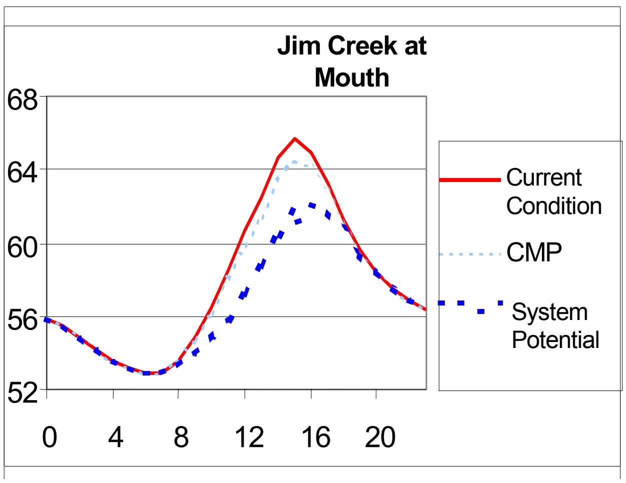
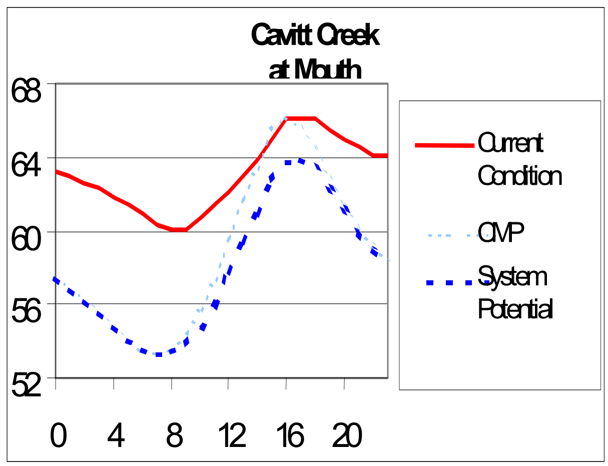
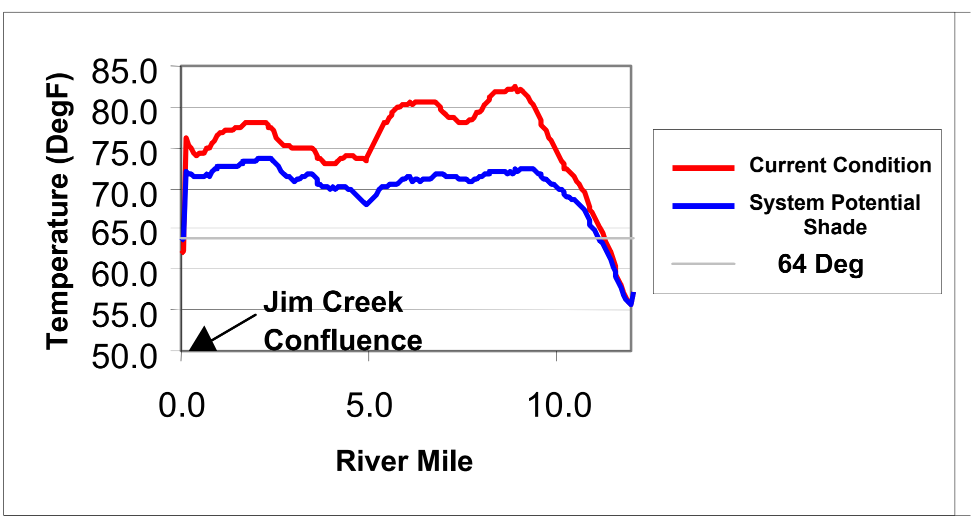


Figure 23b



Cavitt Creek provides examples of two important principles. Figure 24 shows the temperature profiles for current conditions and at system potential. While increased shading does reduce temperatures, it is a minimal improvement. Cavitt Creek runs predominately North-South. Even with increased riparian shading, the southern horizon is never fully obscured from solar energy inputs. Projected temperatures are never below the desired 64 degree F benchmark.

Figure 24



The second important principle here is the effect of Jim Creek on Cavitt Creek temperature. Projected cooling in Jim Creek is enough to cool Cavitt at the mouth to below the 64 degree F benchmark. If each of the other tributaries to Cavitt Creek were cooled to the same degree as Jim Creek, the temperature profile of Cavitt Creek would be significantly lower. Indeed, the only likelihood of reducing temperatures significantly in Cavitt Creek is via tributary cooling.

APPENDIX B – DEPARTMENT OF ENVIRONMENTAL QUALITY

pH modeling report

Little River
pH Model

DEQ Headquarters
January 30, 2001

State of Oregon
Department of Environmental Quality

The following sections discuss the theory and application of the pH model used to determine the periphyton loading capacities.

Photosynthesis and the Carbonate Buffering System

Periphyton is important because of its ability to photosynthesize. The essence of the photosynthetic process centers about chlorophyll containing plants that can utilize radiant energy from the sun, convert water and carbon dioxide into glucose, and release oxygen. The photosynthesis reaction can be written as (Thomann and Mueller, 1987):

$$6\,CO_2 + 6H_2 0 \xrightarrow{\text{photosynthesis}} C_6H_{12}O_6 + 6\,O_2$$

Equation 1

Periphyton obtains energy from the sun for this daytime process. Instream dissolved oxygen is produced by the removal of hydrogen atoms from the water. The photosynthesis process consumes dissolved forms of carbon during the production of plant cells. Periphyton requires oxygen for respiration, which can be considered to proceed throughout the day and night (Thomann and Mueller, 1987). Carbon dioxide (CO_2) is produced during the respiration process as represented by the following equation:

$$6\,CO_2 + 6H_2 0 \xleftarrow{\text{Respiration}} C_6H_{12}O_6 + 6\,O_2$$

Equation 2

The consumption of CO_2 during photosynthesis and CO_2 production during respiration has no direct influence on alkalinity. Since alkalinity is associated with a charge balance, changes in CO_2 concentrations result in a shift of the carbon equilibrium proton balance and the pH of the solution. (The pH of a solution is defined as an expression of hydrogen-ion concentration in terms of its negative logarithm (Sawyer and McCarty, 1978.)) However, it can be shown that photosynthesis would result in limited alkalinity changes through the uptake of charge ions, such as ortho-phosphorus ($PO4^-$), nitrate (NO_3^-), and ammonia ($NH3^+$).

Carbon dioxide is very soluble in water, some 200 times greater than oxygen, and obeys normal solubility laws within the conditions of temperatures and pressures encountered in fresh water ecosystems (Wetzel, 1983). Dissolved CO_2 hydrates to yield carbonic acid ($CO_2 + H_20 \Leftrightarrow H_2CO_3$). The concentration of hydrated carbon dioxide ($CO_{2(aq)}$) predominates over carbonic acid in natural waters and it is assumed that carbonic acid is largely equivalent to hydrated carbon dioxide (e.g. $[H_2CO_3^*] \cong [CO_{2(aq)}]$) (Snoeyink and Jenkins, 1980).

Carbonic acid dissociates rapidly relative to the hydration reaction to form bicarbonate ($H_2CO_3^* \Leftrightarrow H^+ + HCO_3^-$). In addition, bicarbonate dissociates to form carbonate ions ($HCO_3^- \Leftrightarrow H^+ + CO_3^{2-}$). The various components of the carbonate equilibria are interrelated by temperature dependent constants (i.e. pK_{a1} and pK_{a2}, respectively) which establishes an equilibrium between $H_2CO_3^*$, HCO_3^-, and CO_3^{2-}:

$$HCO_3^- + H_2 0 \Leftrightarrow H_2CO_3^* + OH^-$$
$$CO_3^{2-} + H_2 0 \Leftrightarrow HCO_3^- + OH^-$$
$$H_2CO_3^* \Leftrightarrow H_2 0 + CO_2$$

Equation 3

From these dissociation relationships, the proportions of $H_2CO_3^*$, HCO_3^-, and CO_3^{2-} at various pH values indicate that $H_2CO_3^*$ dominates in waters at pH 5 and below. Above pH of 9.5 CO_3^{2-} is quantitatively significant. Between a pH of 7 and 9.5 HCO_3^- predominates (Wetzel, 1983).

Alkalinity is defined as a measure of the capacity of a water solution to neutralize a strong acid (Snoeyink and Jenkins, 1980). In natural water this capacity is attributable to bases associated with the carbonate buffering system (HCO_3^-, CO_3^{2-} and OH^-). The carbonate equilibria reactions given above result in solution buffering. Any solution will resist change in pH as long as these equilibria are operational.

Photosynthesis and respiration are the two major biologically mediated processes that influence the amount of available $CO_{2(aq)}$ in fresh water systems. Accordingly, the pH of the solution will fluctuate diurnally and seasonally in accordance with a change of charge balance resulting from the production and/or consumption of $CO_{2(aq)}$ during these respective processes. Thus, an estimation of $CO_{2(aq)}$ will provide a method to determine pH levels in relation to the carbonate equilibrium proton balance within the solution. The concentration of $CO_{2(aq)}$ (e.g. $H_2CO_3^*$) in solution can be determined as:

$$[H_2CO_3^*] = \alpha_0 C_{tCO3}$$

Equation 4

where α_0 is mathematically defined as (Chapra, 1997):

$$\alpha_0 = \frac{[H^+]^2}{[H^+]^2 + [H^+]Ka1 + Ka1Ka2}$$

Equation 5

where K_{a1} and K_{a2} are equilibrium constants for carbonic acid and bicarbonate ions, respectively, and where the amount of total inorganic carbon (C_{tCO3}) in natural waters is defined as:

$$C_{tCO3} = \frac{Alkalinity - \frac{Kw}{[H^+]} + [H^+]}{(\alpha 1 + 2\alpha 2)}$$

Equation 6

The "Alkalinity" component of Equation 6 is expressed in milliequivalents (meq). The "Kw" term is a temperature-dependent equilibrium constant for water and can be defined as:

$$K_w = [H^+][OH^-]$$

Equation 7

The"α_1" and "α_2" terms in Equation 6 are mathematical definitions of ionization fractions (Chapra, 1997):

$$\alpha_1 = \frac{[H^+]k_{a1}}{[H^+]^2 + [H^+]K_{a1} + K_{a1}K_{a2}}$$

Equation 8

$$\alpha_2 = \frac{K_{a1}K_{a2}}{[H^+]^2 + [H^+]K_{a1} + K_{a1}K_{a2}}$$

Equation 9

An increase in instream CO_2 results in a lower pH. Conversely, a decrease in CO_2 results in a higher pH. The consumption of CO_2 during periphyton photosynthesis causes elevated pH levels between the Little River at rivermile 14.7, 8.0 and 0.6 monitoring sites.

PH MODEL

The impact of algal production on pH can be determined by a mass balance of the carbonate species. Assuming that the consumption of carbon is consistent along the river bottom, the change in total carbonate species can be estimated as the amount of $CO_{2\,(aq)}$ plus the amount brought in by aeration and production, minus the amount of carbon dioxide consumed over time:

$$C_{CO2(aq)T} = C_{CO2(aq)E} - (\{[C_{CO2(aq)E} - C_{CO2(aq)T}]e^{-ka_{CO2}T}\} + \{[1 - e^{-ka_{CO2}T}][\frac{P_{aCO2}}{K_{aCO2}}]\})$$

Equation 10

where:

$C_{CO2(aq)}$ = Dissolved CO_2 (e.g. $[CO_{2(aq)}] \approx [H_2CO_3^*]$) (mmoles/l); and
E = Equilibrium Condition @ Time = 0;
T = Time (day);
K_{aCO2} = Inorganic carbon gas transfer rate from the atmosphere (day^{-1});
P_{aCO2} = Periphyton consumption of CO_2 (mmoles CO_2/mg O_2/l * day).

Periphyton oxygen production is developed through an analytical formula developed by Di Torro (1981) that relates the observed range of diurnal dissolved oxygen (Δ_{DO}), depth (H), and aeration coefficient (Ka_{O2}) to a measure of maximum potential benthic oxygen production (P_{aO2}):

$$P_{aO2} = (\frac{0.5Ka_{O2}[1 - e^{-KaO2}]}{[1 - e^{(-0.5Ka_{O2})}]^2})(\Delta_{DO})(H)$$

Equation 11

Equation 11 is a method to calculate the amount of oxygen produced by periphyton per bottom area normalized by depth (mg/l-day). The stoichiometric equivalent of carbon consumed during the photosynthetic process was determined by a simple mass balance relationship which defines the amount of oxygen produced during photosynthesis to the amount of carbon consumed (Equation 1). Specifically, P_{aO2} (Equation 11) was converted to carbon consumed during the photosynthetic process (Chapra, 1997) and incorporated into the model:

$$\text{Oxygen to Carbon Coversion} = \frac{6 \text{ mmole } CO_2}{6 \times 32 \text{ mg}O_2} = 0.03125 \frac{\text{mmole } CO_2}{\text{mg}O_2}$$

Equation 12

Equation 10 is analogous to classical dissolved oxygen balances, with the exception that only the free carbon ($[CO_{2(aq)}] \approx [H_2CO_3^*]$) portion of the total carbonate concentration is involved in the aeration equilibrium calculations. Neglecting the influence of buffers other than the carbonate system, and assuming that total alkalinity does not change, the pH can then be estimated from the application of these equations. Changes in free carbon (e.g. $[CO_{2(aq)}] \approx [H_2CO_3^*]$) and total carbonate species (e.g. $[C_tCO_3]$) due to photosynthesis and respiration were calculated through the application of Equation 10. At the range of pH found in Little River (approximately 6.5-9.0), it can be assumed that most of the carbonate buffers are in the form of bicarbonate HCO_3^- (e.g. $C_tCO_3 \approx HCO_3^-$). The temperature dependent equilibrium constant for bicarbonate (K_{a1}) is defined as:

$$K_{a1} = \frac{[H^+][HCO_3^-]}{[H_2CO_3^*]}$$

Equation 13

Through substitution and rearrangement, pH can be defined as the negative logarithm of $[H^+]$:

$$[H^+] = \frac{K_{A1}[CO_{2(aq)}]}{[C_tCO_3]}$$

Equation 14

where $[C_tCO_3]$ and $[CO_{2(aq)}]$ are determined through the application of Equation 10.

The carbon balance presented in Equation 10 is expressed in terms of a deficit, and is defined as the difference between saturation and existing concentrations. The carbon deficit will increase due to carbon uptake from periphyton and decrease from gas exchange (Chapra, 1997). The carbon equilibrium level in water is defined as saturation, at which point no net diffusion exchange of carbon between air and the water will occur. The carbon exchange rate between air and water depends on both the differences between existing carbon concentrations and saturation, as well as water turbulence. For example, carbon diffusion rates will increase at a greater carbon deficit and water turbulence levels. This process is similar to re-aeration in streams.

It is assumed that the dominant carbon balance processes are photosynthetic uptake (i.e. periphyton uptake) and carbon re-areation (i.e. gas exchange). By assuming that the uptake of carbon and equilibrium reactions occur at a greater rate than replacement of carbon through aeration, the response of pH to reduced carbon concentration can be modeled. Accordingly, the carbon balance accounts for the current deficit, the amount of carbon brought in through aeration due to that deficit, the amount of carbon lost due to photosynthesis and the amount of carbon brought in through aeration due to the increase deficit resulting from photosynthesis.

The impact of algal production on pH was determined by solving the inorganic carbon mass balance up to a pH of 9.5. Above 9.5, the solution was assumed to be simply greater than 9.5 in order to simplify the calculations (e.g. available inorganic carbon is significantly curtailed at pH values equal or above 9.5.).

APPLICATION OF THE MODEL

Model Time Step

A simple steady state analysis does not provide information on how effective nutrient control may be downstream of the nutrient source because uptake from benthic algae reduces the available nutrient supply. Accordingly, a time dependent solution of the inorganic carbon balance was used to assess the potential influence of diurnal pattern of photosynthetic activity. A time dependent determination of total carbonate (C_tCO_3) and hydrated carbon dioxide ($CO_{2(aq)}$) provided a method to estimate in-stream pH levels resulting from increased periphyton production rates downstream of a source of pollution. The time step was modeled at a ten-minute interval.

CO_2 and O_2 Aeration Rate

The carbon mass balance equations in this model are extremely sensitive to the estimated, or assumed, ratios between aeration (Ka_{O2}) and production (P_a) rates. It can be shown that a decreased gas transfer or increased benthic consumption rate would increase the rate which the $CO_{2(aq)}$ deficit develops, and therefore result in an increase in-stream pH. In addition, increased depths would decrease the relative impact from periphyton production rates (P_a). The distance or the time required to exceed water quality standards is dependent on the availability of inorganic carbon concentrations of the water entering the section of the river, or from other sources such as tributaries, groundwater, or atmospheric aeration of CO_2.

Aeration rates (K_{aO2}) were estimated through the use of the Tsivoglou and Wallace (1972) formula. The formula was developed using a database of direct measurement of re-aeration:

$$K_{aO2} = 0.88US$$

Equation 15

Where K_{aO2} is in day^{-1} at 20*C, *S* is the slope in feet/mile, and *U* is the velocity in feet per second. More recent comparisons by Grant and Skavroneck (1980) indicated that this expression is most accurate for small shallow streams (Thomann and Mueller, 1987).

There is little literature describing aeration rates for inorganic carbon (Ka_{CO2}). Tsivoglou (1967) found during a series of laboratory tests that the mean ratio for dissolved oxygen (Ka_{O2}) and inorganic carbon aeration rates (Ka_{CO2}) to be 0.894 with a range of 0.845 to 0.940 and a standard deviation of 0.034. Simonsen and Harremoest (1978) determined aeration rates in a river using a twin curve method for both carbon and oxygen and found that the Ka_{CO2} averaged 0.57 Ka_{O2}. It was assumed that the aeration rates for inorganic carbon followed the relationship presented by Simonsen and Harremoest (1978).

Periphyton Growth

The rate of periphyton growth is limited by the **availability of light**, **nutrients**, **and water temperature. In a situation where the available light for periphyton growth is at an optimum level and nutrients are plentiful, then the growth of periphyton will be dependent on the temperature effect** (Thomann and Mueller, 1987). If all of these are available in excess (i.e. non limiting condition), then dense mats of periphyton will grow and the algal mass will then be regulated by grazing by macro-invertebrates, grazer predation, substrate characteristics, and hydraulic sloughing.

Potential periphyton growth was assumed to occur proportional to the calculated growth rate from light availability (G_L) and the calculated growth rate from nutrient (G_N) concentration, whichever rate is lowest. It was assumed that the calculated production rate of oxygen (P_{AO2}) (see Equation 11) was proportionately reduced by these periphyton growth rate functions:

$$\text{Potential Periphyton Growth} = \text{Minimum}\,(G_N \text{ or } G_L) * P_{AO2}$$

Equation 16

In addition, a component to estimate periphyton growth response to changes in stream temperature (G_T) was used to estimate the instream pH in Little River from rivermile 26.0 to the mouth given instream temperatures ranging from 15 to 22 degrees C.

Algal Growth Factor - Availability of Light (G_L)

Increased Solar Radiation has been shown to increase pH by encouraging photosynthetic chemical reactions associated with primary production (DeNicola et al., 1992). Increased algal productivity in response to increased solar exposure has been well documented (Gregory et al., 1987; DeNicola et al, 1992). In addition, it has been shown that photosynthesis of benthic algal communities in streams reaches a maximum at low light intensities (Gregory et al., 1987; Powell, 1996).

The effect of solar radiation on periphyton productivity (G_L) was added to model calculations, and was assumed to follow a sinusoidal curve described by Simonsen and Harremoest (1978):

$$G_L = \cos\frac{2\pi}{\alpha}t$$

Equation 17

where alpha is the length of day (assumed 16 hours/day) and t is the time of day and is represented in **Figure 4**.

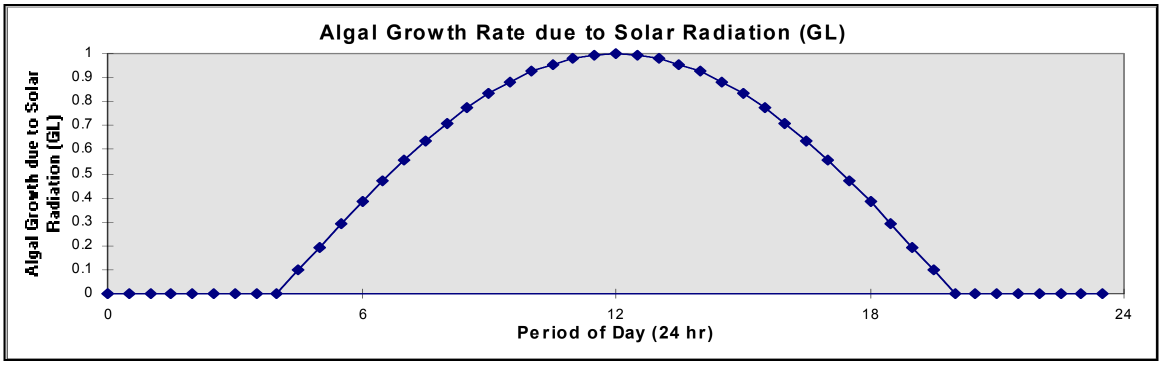


Figure 4: Algal Growth Rate due to Solar Radiation (GL)

Algal Growth Factor - Nutrients (G_N)

Algae (periphyton) production due to phosphorus concentrations, as well as periphyton nutrient uptake, was assumed to follow the Michaelis-Menton model of enzyme kinetics: Algae production and nutrient uptake due to available nutrients (G_N) was assumed to be relative to the availability of in-stream dissolved orthophosphorus (**Figure 5**).

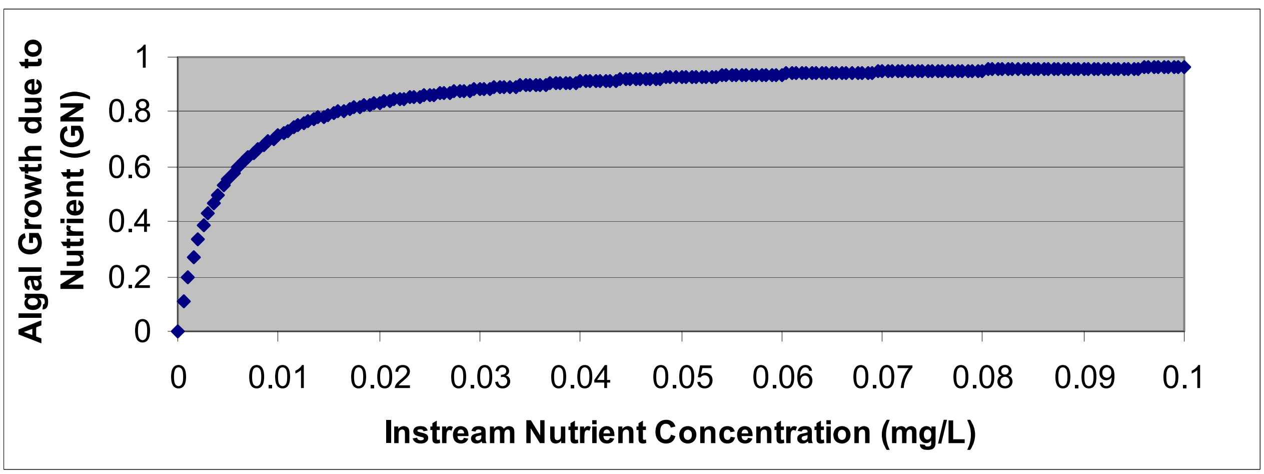


Figure 5: Algal Growth rate due to instream nutrient concentration (G_N)

A conservative 0.004 mg/l Michaelis-Menton half saturation constant (K_S) was used in the model to calculate G_N. This value corresponds to an algal growth rate which is one half (0.5) the maximum rate. Typical phosphorus half saturation constants found in literature for benthic algae range from 0.004 to 0.008 mg/l.

If a nutrient control program is initiated, but the reduction in input load only reduces the nutrient concentration to a level of about two to three times the Michaelis constant, then there will be no effect on the algal growth. This is equivalent to the notion of the limiting nutrient. Removing a nutrient that is in excess will not have any effect on growth until lower concentrations are reached. The treatment program may then be ineffective. The nutrient effect on algal growth, therefore, is a marked contrast to other types of water quality problems where reductions in input load (as in biochemical oxygen demand reduction) can generally be considered as being advantageous (Thomann and Meuller, 1987).

Horner et al. (1990), conducting research in laboratory streams, observed that nutrient uptake by filamentous algae increased most dramatically as Soluble Reactive Phosphorus (SRP) concentrations increased up to 0.015 mg/l, and decreased beyond 0.025 mg/l. The author noted that this information corroborates results presented in Horner et al. (1983): Working with the attached filamentous green algae *Mougeotia* sp., Horner et al. (1983) reported that algal accrual increased in proportion to increased SRP up to about 0.025 mg/l, but further increases were not as pronounced above that concentration, presumably due to a saturation of uptake rates.

Bothwell (1989) reported that maximum algal growth occurred at ortho-phosphorus concentration of 0.028 mg/l. However, this author reported that there appears to be differences between saturation growth rates and biomass accrual rates, with algal cellular requirements saturated at ambient phosphorus levels between 0.003 - 0.004 mg/l (Bothwell, 1992). However, many researchers have found that much higher levels of phosphorus are required to produce algal bloom problems in streams and rivers (Horner et al., 1990; Horner et al., 1983; Welch et al., 1989). Discrepancies may arise because of species differences, differing physical factors, the influences of algal mat thickness and community nutrient requirements, and the dynamics of nutrient spiraling. Accordingly, it was assumed that the algal growth, and subsequently the phosphorus uptake rate, was saturated at in-stream concentrations greater than 0.025 mg/l.

It is important to note that Bothwell (1985) observed that additions of multiple nutrients have a greater stimulatory effect on periphyton than estimated from single nutrients as assumed in this modeling work. Accordingly, pH modeling simulations may underestimate the actual production rates resulting from nutrient additions (G_N) that would be observed in the river.

Algal Growth Factor - Temperature (G_T)

The assimilative capacity of a water body is often proportional to temperature because of its influence on equilibrium conditions and several biological and chemical reaction rates. In a review of laboratory studies, field studies and mathematical models, O'Connor (1998) demonstrated that the gas transfer rate between the water surface and overlying atmosphere, rather than the carbonate equilibrium reaction rate, was the controlling mechanism for pH change resulting from temperature changes. Therefore the analysis of assimilative capacity at different temperatures focuses on factors influencing CO_2 exchange and not the carbonate equilibrium reaction.

Specific temperature dependent functions affecting CO_2 exchange include in this model are: 1) CO_2 saturation; 2) maximum algal growth rate (expressed as the photosynthetic demand of carbon); and 3) CO_2 aeration. Temperature influences were estimated by multiplying the ratio between the estimated rate at predicted temperatures and the calculated rate at initial conditions, which was calibrated using observed field temperature data.

The saturation level of carbon dioxide is related to temperature through Henry's law and is calculated as a function of temperature and altitude according to USEPA (1986); and as expressed by Caupp et al. (1997):

$$CO_2\ \text{Saturation} = 10^{-\left(\frac{-2385.73}{\text{Temp}}+14.01884-0.0152642*\text{Temp}\right)} * 3.162*10^{-4} * e^{\frac{(-0.03418\ *\ \text{Elivation})}{(288.0\ -\ 0.006496\ *\ \text{Elivation})}} * 44000$$

Equation 18

where Temp is water temperature in Kelvin, and Elevation is elevation in meters.

The influence of temperature on the CO_2 aeration rate is modified using the Arrhenius relationship with a standard reference to 20 ^{O}C. The USEPA Document (1985) identified a typical range of theta values between 1.022 and 1.024, with a reported range of 1.008 to 1.047. This range was developed for the simulation of dissolved oxygen. A theta value of 1.02 identified by O'Connor (1998) for CO_2 was used:

$$K_t = K_{20}\ \theta^{(Temperate\ (^{o}C)\ -\ 20\ ^{o}C)}$$

Equation 19

where K_t is the CO_2 aeration rate at temperature (t), and K_{20} is the CO_2 aeration rate at 20 ^{O}C.

Temperature effects on the algal growth rate were related directly to maximum production rate (P_{AO2}) (Equation 11). Algal growth rate, expressed as photosynthetic demand of carbon, was adjusted for temperature using the equations presented by the USEPA (1986):

$$\text{Algal Growth}_{\text{(Temperature)}} = \theta^{\text{(Temperature (C) - 20 (C))}}$$

Equation 20

Typical theta values were reported by USEPA to range between 1.01 and 1.2. Epply (1972) reported a theta of 1.066. This value was used in the model.

Initial Buffering Capacity

Initial alkalinity, pH and temperature of Little River were included in the carbon balance calculations in the model.

Algal Biomass Accrual

Results obtained from the application of this model do not simulate algal biomass accrual, but it provides a method to calculate an assumed diel production (≈ growth) pattern. A simple procedure proposed by Horner et al. (1983) and discussed by Welch et al. (1989) provides a steady state kinetic prediction of the potential periphyton biomass accrual based on physical and chemical characteristics of the river and their influence on algae growth rates and accumulation. The model was originally calibrated against the growth of filamentous green algae in artificial channels over a range of velocities and phosphorus concentrations. Application of the model with site specific data from the Spokane River, Washington (Welch et al., 1989) and the Coast Fork Willamette River, Oregon (DEQ 1995-b) indicated that the rate of biomass accumulation reduced proportionally to that of in-stream limiting nutrient concentrations, and that the rate of bioaccumulation was expected to decrease downstream as uptake removed the limiting nutrient. In addition, it was also hypothesized that periphyton biomass will eventually approach maximum levels even at low in-stream nutrient concentrations following a sufficiently long growing season.

Invertebrate Grazing

The pH model described above does not estimate the potential effects of grazing by macroinvertebrate on the standing crops and net production of the periphyton community. Grazing may influence not only standing crop, but also nutrient uptake and recycle rates, as well as species distribution within the benthic algal mat. Grazing generally results in lower periphyton biomass (Lamberti et al., 1987 and; Welch et al., 1989), a simplified algal community, lower rates of carbon production, and a constraint nutrient cycling (Mulholland et al., 1991). Reduced production rates anticipated under a nutrient control strategy would likely increase the relative influence of grazing as a controlling mechanism on periphyton. Hence, periphyton biomass accrual rates in Little River may be lower than predicted by the model as a result of a relative increased invertebrate grazing pressure at the anticipated reduced periphyton growth rates.

Model Calibration

The model was calibrated using streamflow and continuous pH data collected during August, 2000. The streamflow measured during the survey was 13 cubic feet per second, which is near the historic 7Q10. As can be seen in **Figures 6 and 7** below, the model-calculated pH was very close to the observed pH.

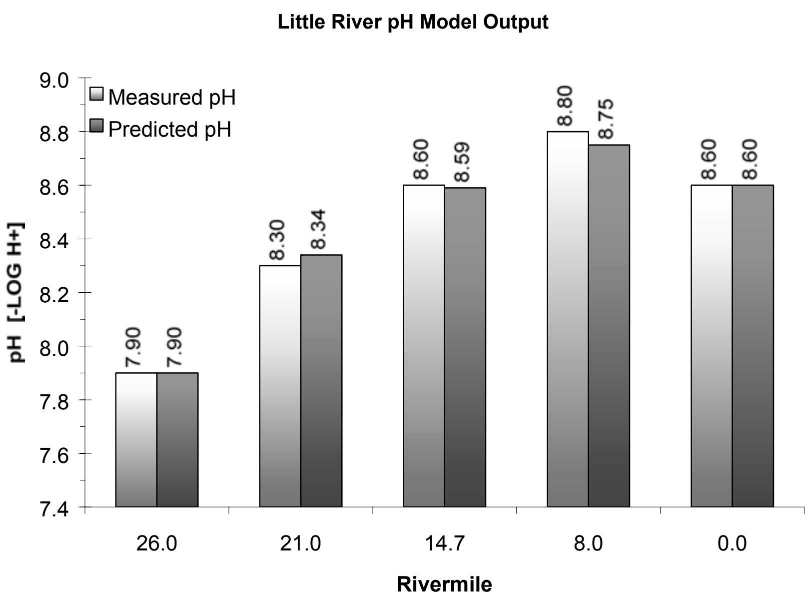


Figure 6: Little River pH Model Output

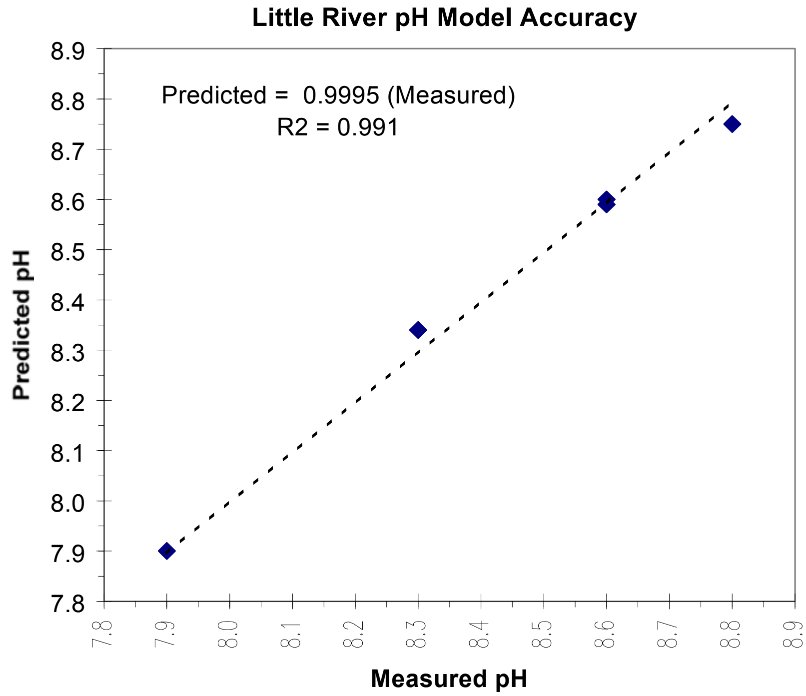


Figure 7: Little River pH Model Accuracy

The temperature model of the Little River predicts system potential maximum temperatures at rivermiles 21.0, 14.7 and 8.0 of 16.0, 17.0, and 17.0 degrees F, respectively. The pH model predicts that the maximum instream pH at rivermile 14.7 will be 8.3 SU with the river achieving system potential temperatures (**see model output in Figure 8**). The pH predicted at system potential temperature near the mouth of Little River is 8.4 SU. **The loading capacities for periphyton are the system potential stream temperatures discussed above.**

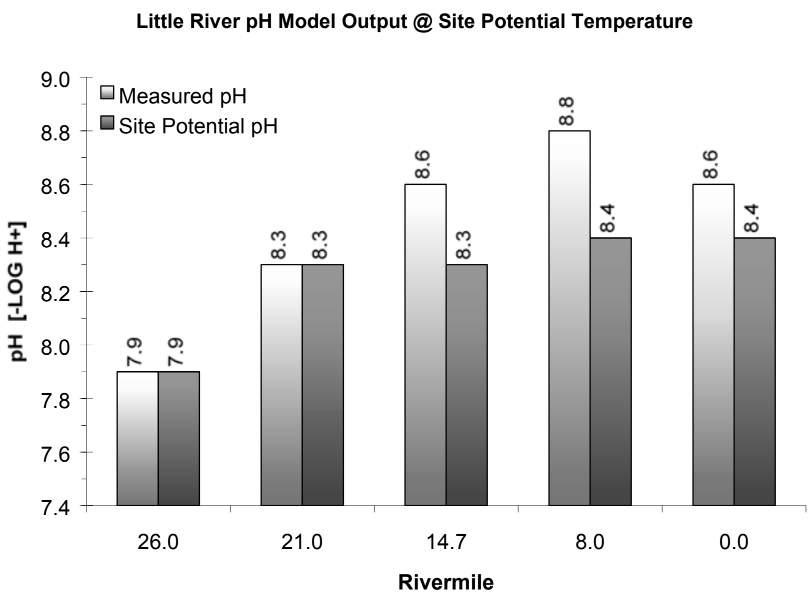


Figure 8: pH Model Output at System Potential Temperatures

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APPENDIX C - U.S. FOREST SERVICE, U.S. BUREAU OF LAND MANAGEMENT

Federal Water Quality Restoration Plan

Water Quality Restoration Plan

Umpqua Basin
Little River Watershed

Roseburg District BLM
Umpqua National Forest

February, 2001

Statement of Purpose

This water quality restoration plan is prepared to meet the requirements of Section 303(d) of the 1972 Federal Clean Water Act.

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I. Condition Assessment and Problem Description

A. Introduction

Little River Watershed

The area covered by this plan includes all lands within the Little River Watershed managed by the Umpqua National Forest (USFS) and the Bureau of Land Management, Roseburg District (BLM). The federal lands within the watershed comprise the Little River Adaptive Management Area (AMA), one of ten AMA's throughout the Pacific Northwest. AMA's were designated by the Northwest Forest Plan (NWFP) as places to encourage the development and testing of technical and social approaches to achieving the ecological, economic, and other social objectives as described in the NWFP. The specific emphasis of the Little River AMA is the development and testing of approaches to integration of intensive timber production with restoration and maintenance of high quality riparian habitat.

Watershed at a Glance	
Watershed	Little River (131, 850 acres; 206 mi^2) . USFS Managed (63,590 acres) . BLM Managed (19,274 acres) . Private Ownership (48,986 acres)
Stream Miles	Total (741 Miles) . Public Ownership (410 Miles) . Private Ownership (331 Miles) Perennial (168 Miles) . Public Ownership (91 Miles) . Private Ownership (77 Miles)
Watershed Identifier	1710030111 (Hydrologic Unit Code)
303 (d) Listed Parameters	Temperature, pH, Sediment, Habitat Modification
Beneficial Uses (per Oregon's 303d Listing Criteria)	Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing, Water Contact Recreation

Figure 1. Little River watershed statistics. Stream miles taken from latest BLM stream data.

In general terms, a watershed can be defined as any bounding area where water drains to a specified outlet. To better classify watersheds they are commonly divided into size categories called fields. The largest classification of this kind is termed a 1st field watershed (also called a Region). As part of the ranking system, 1st fields break down into smaller 2nd fields (Sub-Regions) which then can be broken into 3rd fields (Basins) and then 4th fields (Sub-Basins). Recently, there has been a need to further divide into smaller units. As a general rule, each 4th field is subdivided into roughly 5 to 15 new units called 5th fields (Watersheds). A typical size for this watershed drainage area is from 40,000 to 250,000 acres. The typical size of a 6th fields unit (Sub-watershed), a subdivision of a watershed, is

10,000 to 40,000 acres. Little River is a 5th field watershed and it has been divided into 13 6th field sub-watersheds. This document uses the terms watershed and sub-watershed to describe these 5th and 6th field units.

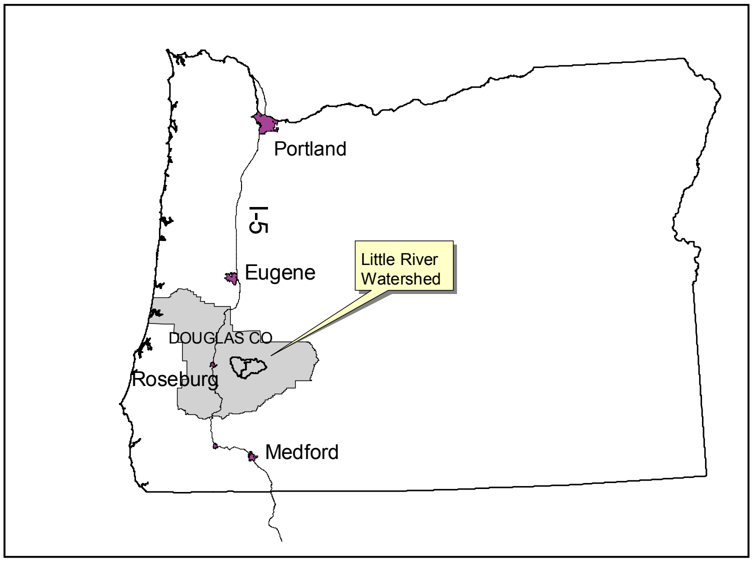

Figure 2. Location of Little River watershed.

Listing Status

Little River and several tributaries have been placed on the Oregon 303(d) list due to documented violations of water quality standards (DEQ 1998). Figures 3 through 5 show the listed parameters, locations, beneficial uses and extent of the listings. The listed parameters encompass 55 miles. This is 7% of the total streams and 21% of perennial streams.

Location	Parameter(s)
Black Creek, (mouth to headwaters)	Rearing Temperature
Cavitt Creek (mouth to headwaters)	Rearing Temperature
Cavitt Creek, (mouth to Evarts)	pH
Cavitt Creek, (mouth to Plusfour Creek)	Sediment, Habitat Modification
Clover Creek, (mouth to headwaters)	Rearing Temperature
Eggleston Creek, (mouth to headwaters)	Rearing Temperature
Emile Creek, (mouth to river mile 1.0)	pH
Emile Creek, (mouth to headwaters)	Rearing Temperature
Flat Rock Creek, (mouth to headwaters)	Rearing Temperature
Jim Creek, (mouth to river mile 2.0)	Rearing Temperature
Little River, (mouth to Hemlock Creek)	Rearing Temperature, Sediment, Habitat Modification
Little River, (Hemlock Creek to headwaters)	Sediment, Habitat Modification

Location	Parameter(s)
Little River, (mouth to White Creek)	pH
Wolf Creek, (mouth to headwaters)	Rearing Temperature
Wolf Creek, (mouth to major falls)	pH

Figure 3. Streams within the Little River watershed that do not meet State water quality standards (1998).

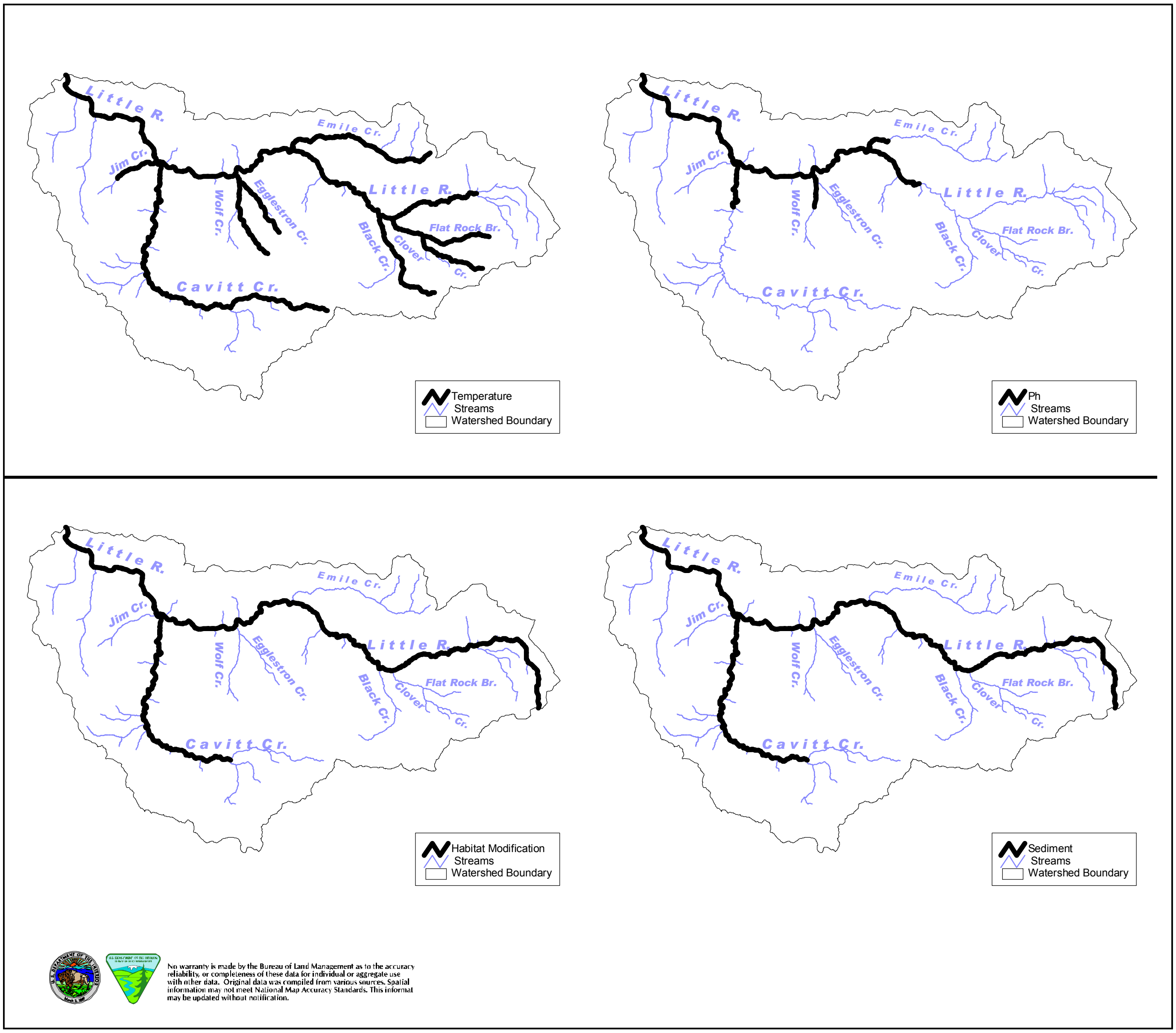

Figure 4. Little River watershed, 303(d) listed streams.

Based on the large numbers of juvenile anadromous salmonids leaving Little River, this system is an important tributary to the North Umpqua River for spawning and rearing habitat. Stream surveys indicate that 48 miles of streams in the watershed support anadromous species, primarily in the larger, main stem of Little River and Cavitt Creek. Anadromous fish distribution is often limited by waterfalls or steep gradient cascades in tributaries.

Resident, or non-anadromous trout also occur naturally (rainbow and cutthroat) or have been introduced for recreational purposes (brook trout and kokanee). Several other species of introduced game fish also inhabit the Little River system, as do numerous native non-game species. Various species of amphibians and reptiles occur in the watershed including sensitive species such as the tailed frog, red-legged frog, yellow-legged frog, cascade frog, southern torrent salamander, and western pond turtle (Little River Watershed Analysis 1995).

Resident Fish & Aquatic Life	<u>Anadromous</u> <u>Fish:</u> Spring chinook, fall chinook, coho (t), summer and winter steelhead trout (c), sea-run cutthroat trout (c), Pacific lamprey (co) <u>Resident</u> <u>Fish:</u> Rainbow trout, cutthroat trout (c), brook trout (n), kokanee salmon (n), and numerous other non-game species <u>Other</u> <u>Aquatic</u> <u>Life</u>: tailed-frog (s), yellow-legged frog (s), red-legged frog (s), pacific giant salamander, cascade frog (s), southern torrent salamander (s), Dunn's salamander, western pond turtle (s), beaver, river otter, and numerous other species of frogs, salamanders, turtles, & snakes
Salmonid Spawning & Rearing	Spring chinook, fall chinook, coho , summer and winter steelhead trout, sea-run cutthroat trout, Pacific lamprey
Water Contact	Swimming, rafting, fishing in ponds/lakes

Figure 5. Beneficial uses in the Little River watershed. Federal ESA designation noted as (t) = threatened; (c) = candidate; (co) = species of concern; (s) = sensitive, and (n) = non-native.

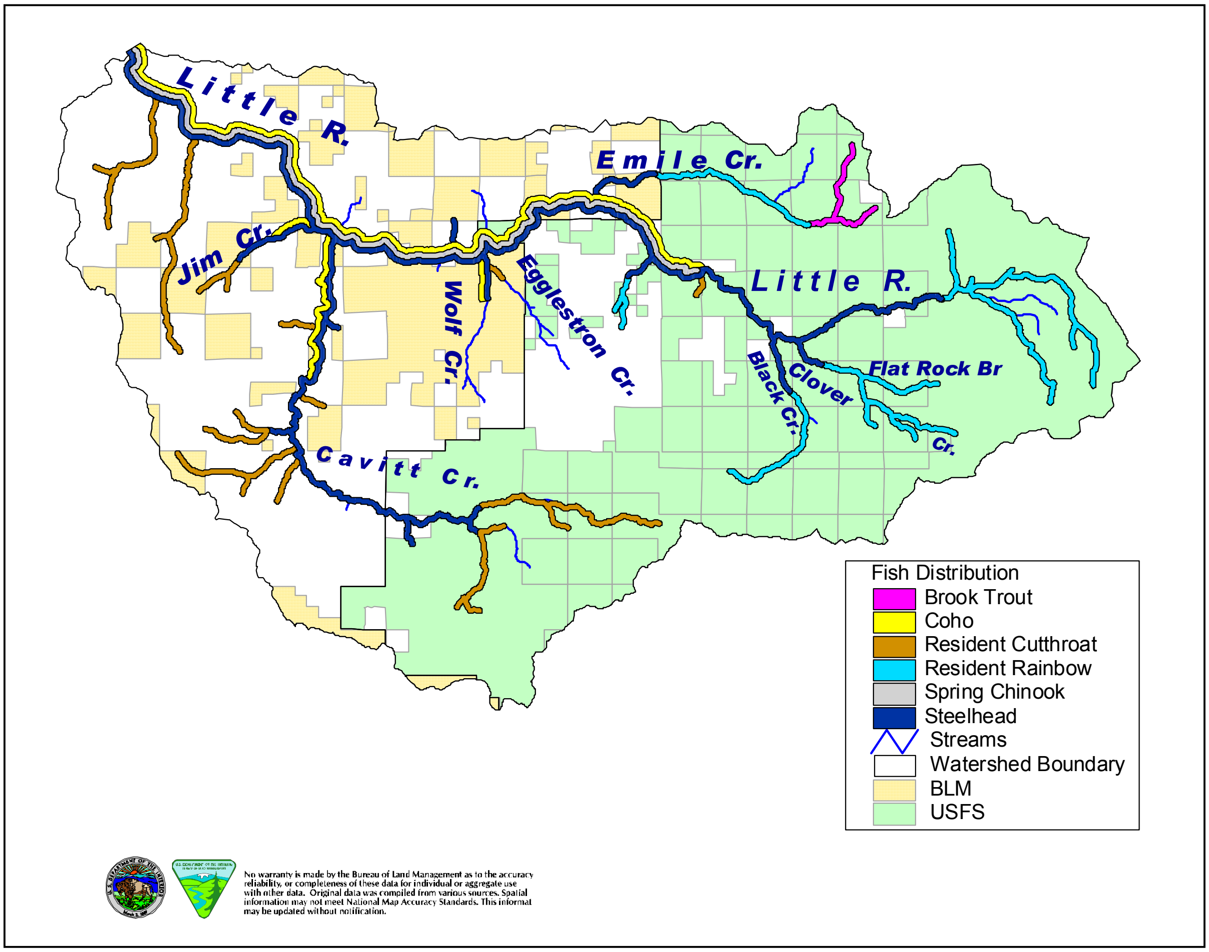

Figure 6. Fish Distribution in the Little River watershed.

The primary elements that are likely limiting fish populations within the basin are high water temperature during the summer, excess fine sediment, extensive areas of oversimplified habitat, and increased peak flows (Watershed Analysis 1995). When considered separately, it is not likely that each of these attributes could solely be responsible for degraded aquatic habitat conditions for fish species. However, when considered cumulatively, all these factors add up to an aquatic environment that is applying stress to populations of aquatic organisms. It is well known that acute or chronic stress approaching or exceeding the physiological tolerance limits of individual fish will impair reproductive success, growth, resistance to disease, and survival (Schreck and Moyle 1990).

Watershed Characteristics

The Little River watershed is located approximately 18 miles east of Roseburg, Oregon, and encompasses 131,853 acres (206 square miles). The watershed lies within the Umpqua Basin (Figure 7). Much of the watershed lies within the western Cascades geologic province (83%), while the Klamath and Coast Range geologic provinces account for 11% and 6% of the watershed, respectively (Little River Watershed Analysis 1995). Elevations within the watershed range between 750 feet (225 meters) at the confluence with the North Umpqua River, to 5,275 feet (1,600 meters) at the headwaters.

High elevations receive over 80 inches of annual precipitation (rainfall equivalent), much of which accumulates as snow at elevations above 2,000 feet. Lower elevations average 40 inches of rainfall annually. The timing of precipitation in the Little River watershed can be separated into a winter season of frequent storm events and a long period of summer drought. The watershed analysis provides a description of typical and peak flows. In late summer, low flows in Little River averaged 25 cubic feet per second (cfs) between 1954 and 1987 at the Peel gauging station located 6.3 miles up from the mouth of Little River. During the same period, winter base flows were typically in the range of 200 to 300 cfs, with flood peaks measured as 22,700 cfs in 1955 (Little River's flood of record), 21,100 cfs in 1956, and 20,900 cfs in 1964. Peak flows have typically varied between 5000 and 15,000 cfs during this period. Rain-on-snow events can potentially trigger high winter and early spring peak flows in Little River.

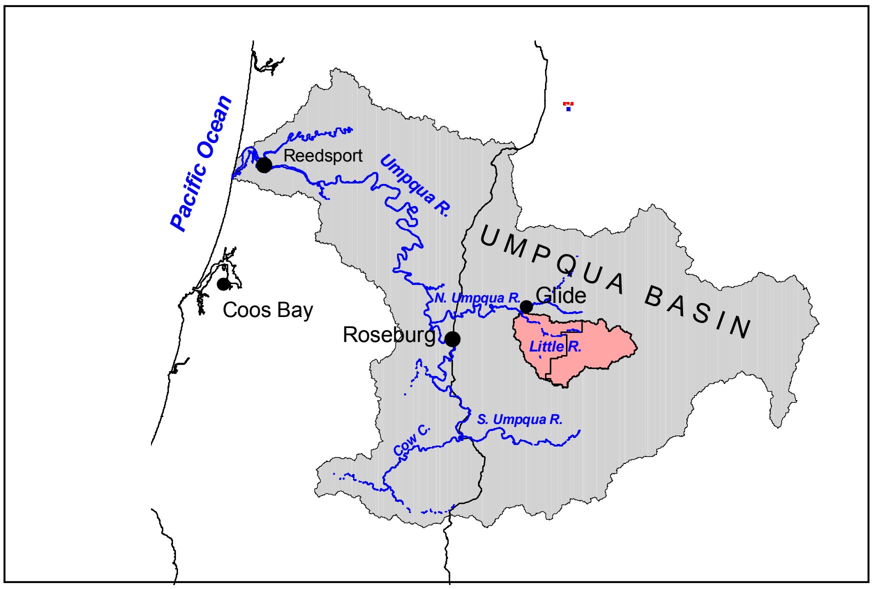

Figure 7. Umpqua basin and the Little River watershed.

The approximate length of the Little River is 26 miles from mouth to headwaters. The watershed has a drainage density of 3.6-mi./square mi.. Figure 8 depicts streams miles by stream order (Strahler 1957). There are various methods for deriving stream order, but all are intended to be measures of the position of a stream in the hierarchy of tributaries within a watershed. First order streams have no adjoining tributaries, while second order streams are formed by the intersection of two first order streams. Stream order helps describe: 1). Stream size and position in the watershed, and 2.) The amount of suitable stream substrate for spawning which varies with the size of stream (order) and salmonid species (Boehne and House 1983). The amount of spawning gravel per kilometer of stream is greatest in 4th order coastal watersheds and 5th order Cascade Range watersheds. The stream miles and orders shown in Figure 8 provide a general representation of the stream system in Little River; however, they were derived from GIS stream layers and have varying degrees of accuracy and completeness.

Sub-watershed	Acres	Stream Miles	Stream Order					
			(Intermittent)		(Perennial)			
			1	2	3	4	5	6
Black Creek	9,660	48	26	11	8	3	0	0
Clover Creek	7,395	34	19	8	5	2	0	0
Cultus Creek	7,751	37	20	9	5	2	0	0
Emile Creek	8,714	35	19	10	6	1	0	0
Little River Canyon	7,714	39	21	8	4	1	5	0
Lower Cavitt Creek	9,025	61	33	14	6	2	0	6
Middle Cavitt Creek	14,129	104	54	27	11	5	7	1
Middle Little River	13,052	56	33	9	7	0	6	0
Red Butte	10,810	58	29	17	4	1	8	0
Upper Cavitt Creek	6,795	33	16	7	8	2	0	0
Upper Little River	7,535	39	21	9	5	3	0	0
Watson Mountain	21,741	156	85	34	16	10	5	7
Wolf Creek	7,530	41	22	10	5	3	0	0
Totals	**131,851**	**741**	**398**	**173**	**90**	**35**	**31**	**14**

Figure 8. Miles of total streams and miles of streams by stream order in Little River by sub-watershed.

Of the 741 miles of streams in the watershed, approximately 3/4 are 1st or 2nd order streams. Many 1st and 2nd order streams do not flow continuously by late summer. Some 2nd order and all 3rd order and greater streams ordinarily flow year-round and are termed perennial.

Land Use and Ownership

Historically, the old growth forests of the western edge of the Cascade Range met the eastern edge of the mixed hardwoods, prairies and conifers of the Umpqua Valley hills. The Little River watershed consists largely of coniferous forests situated in the upper and middle reaches, with mixed hardwood and coniferous forests and prairies in the lower portion of the watershed.

The U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) administer 63% of lands within the Little River watershed (Figures 9 & 10). USFS lands are mostly large, intact blocks, while BLM lands are mostly patchwork in nature (sections/partial sections surrounded by private land). The remaining 37% of the land consists of private lands, much of which is managed as industrial forest. Timber production is the dominant land use activity in the Little River watershed.

	Sub-watershed

	Black Creek	Clover Creek	Cultus Creek	Emile Creek	Little River Canyon	Lower Cavitt Creek	Middle Cavitt Creek	Middle Little River	Red Butte	Upper Cavitt Creek	Upper Little River	Watson Mtn	Wolf Creek
% Federal Land	97	100	99	84	97	34	29	57	49	96	100	23	62

Figure 9. Percentage of Federal land in Little River. Sixty-three percent of the Little River watershed is under federal jurisdiction.

The present condition, composition and age of the vegetation are largely the result of the widespread harvesting and replanting that has occurred since the 1950's. To date, nearly 60% of the watershed has been harvested and replanted. Timber operations involve a number of activities, which can contribute to non-point source pollution. These current or past activities includes road building, timber harvest, log removal in streams, burning, and fertilization.

In 1994, public lands in the watershed were designated an Adaptive Management Area (AMA) under the Northwest Forest Plan (NWFP). The special emphasis for the Little River AMA is the development and testing of approaches to integration of intensive timber production with restoration and maintenance of high quality riparian habitat.

Other land use activities within the Little River watershed include rural residential development, water withdrawal, agriculture, and recreation. Approximately 1,200 people reside in the watershed, translating to a population density of 6 people per square mile. The majority of the people who live in the Little River watershed ranch and farm in the lower portions of the watershed. Latest records show 111 domestic water rights and 109 irrigation rights in the Little River watershed (Water Master, Douglas County). Due to the close proximity to Roseburg, Oregon, and the wide range of quality outdoor activities offered, Little River and its tributaries are a destination for many forms of recreation, including fishing (in ponds), hunting, swimming, hiking, and driving for pleasure. Roads and stream crossings distributed throughout the watershed provide vehicle access to managed forestlands, residences, and recreational areas.

Watershed Analysis

Watershed analyses are a required component of the Aquatic Conservation Strategy (ACS) under the Northwest Forest Plan (NWFP). The Record of Decision (ROD) for the NWFP was signed in April, 1994. A watershed analysis for the Little River watershed was completed in September, 1995. This WQRP tiers to and appends that document. The analysis and recommendations found in this WQRP uses data from the watershed analysis. Additional analysis and recommendations have been included where data was incomplete or new information was available. Figure 11 provides a summary of watershed conditions.

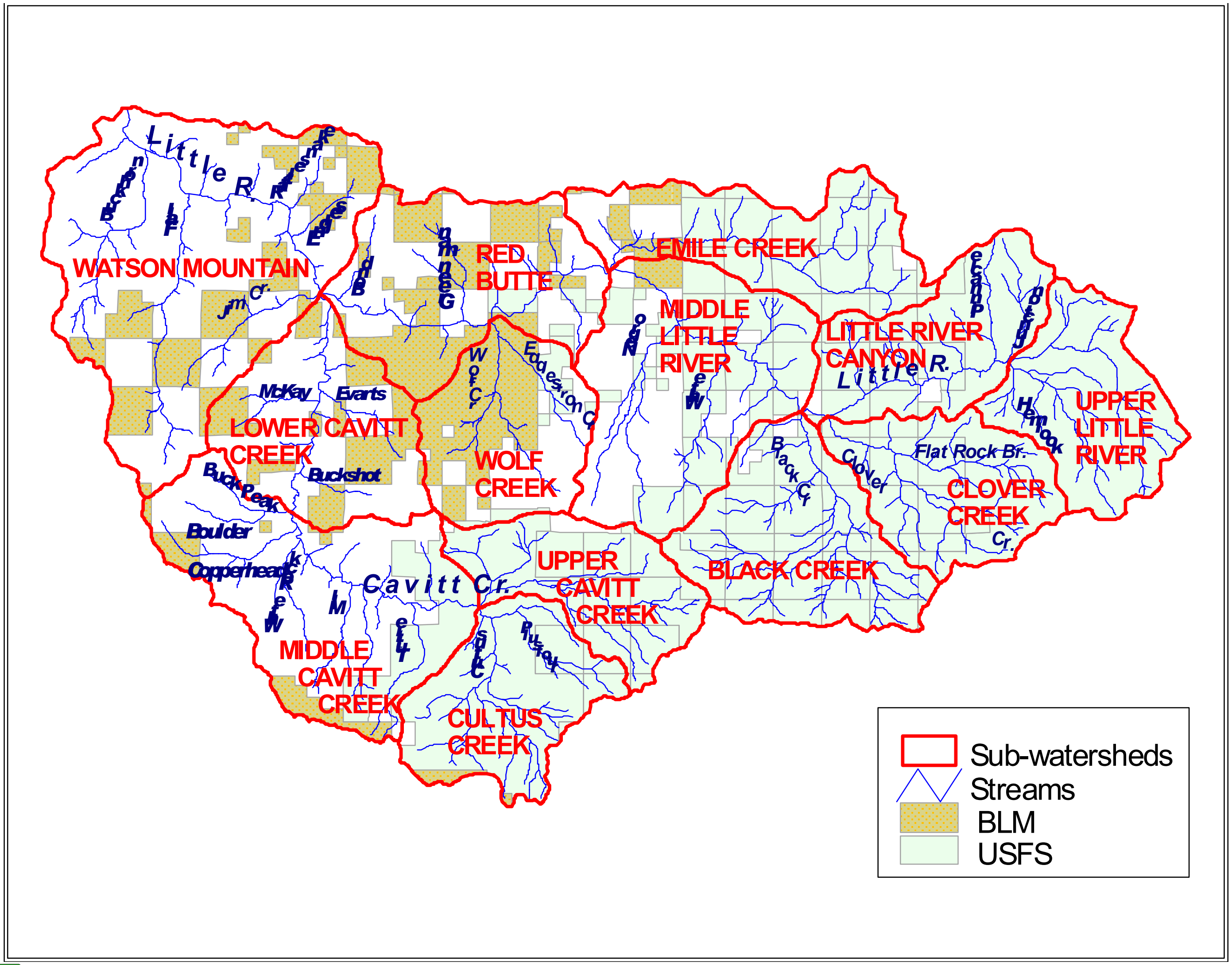

Figure 10. Reference Map of the Little River watershed.

Riparian Vegetation*	
Historical Condition	• Late seral vegetation dominant
Present Condition	• Early to mid seral vegetation dominant • 46% of forest along perennial streams clear-cut harvested • 62% of forest along intermittent streams clear-cut harvested • 90% of wide valley, low gradient riparian areas (Cavitt Creek and Little River) in degraded condition • Large portion of narrow valley, steep gradient riparian areas in degraded condition, riparian salvage and hi-grading common along valley bottoms
Forest Health & Productivity	
Historical Condition	• Frequent, low intensity fires maintained low fuel levels and open under-story
Present Condition	• Fire exclusion resulting in high fuels • Insect populations (mtn. pine beetle) above epidemic levels threaten pine health • Much of harvested lands are densely planted and overstocked (increased competition) • Soil compaction due to tractor harvest
Large Woody Debris	
Historical Condition	• Little or no information is available, reference areas indicate frequent large wood accumulations in the active channel (wood densities of 50 to 100 pieces per mile have been documented in unmanaged streams)
Present Condition	• Many stream sections have little to no large wood • Poor large wood recruitment due to streamside harvest & fire exclusion • Stream crossings disrupt transport of wood and sediment • Stream cleaning has decreased retention of large wood in the active channel (75% of fish bearing streams have been subject to stream cleanout)
Roads	
Historic Condition	• Few roads before industrial timber harvesting began in the early 1950's
Present Condition	• High road density (4.6 mi/mi^2) • Road placement often occurs in riparian areas • High number of stream crossings with many culverts undersized for 100 yr. flood • Stream network extension (due to ditch lines) increases winter peak flows
Flow Regime	
Historic Condition	• Little or no information is available, reference areas such as Boulder Creek indicate that peak flows were lower in magnitude and frequency
Present Condition	• Winter peak flows possibly increased by roads and harvest

Figure 11. Summary of watershed conditions (Little River Watershed Analysis, 1995). *Riparian areas are NWFP ROD buffers applied to the entire watershed for watershed analysis.

B. Temperature

Introduction

For stream temperature, the affected beneficial uses are resident fish & aquatic life and salmonid fish spawning & rearing. Salmonid fish species require specific water temperatures at various stages of their fresh water life:

Life Stage:	Spring Chinook:	Coho:	Cutthroat	Steelhead
Egg Incubation	42.1°F to 55.0°F	39.9°F to 55.9°F	40°F - 57°F	40°F – 57°F
Juvenile Rearing	50.0°F to 58.6°F	53.2°F to 58.3°F	49°F - 55°F	45°F – 58°F
Adult Migration	37.9°F to 55.9°F	45.0°F to 60.1°F	37°F - 68°F	37°F – 68°F
Spawning	42.1°F to 55.0°F	39.9°F to 48.9°F	43°F - 63°F	39°F – 49°F
Upper Lethal Limit	71.6°F	77.0°F	73°F	75°F

Figure 12. Temperature requirements for anadromous salmonids related to fresh water life stages.

The Oregon water quality standard that applies to the Umpqua Basin is OAR 340-041-0285, adopted as of 1/11/96, effective 7/1/96. Excerpts of the standard read as follows:

> *To accomplish the goals identified in OAR 340-041-0129(11), unless specifically allowed under a Department-approved surface water temperature management plan… no measurable surface water temperature increase resulting from anthropogenic activities is allowed:*
>
> *(i) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64° F (17.8° C);*
>
> *(ii) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55° F (12.8° C)*

A stream is listed as water quality limited if there is documentation that the moving (7) day average of the daily maximum exceeds the appropriate standard listed above. This represents the warmest seven-day period and is calculated by a moving average of the daily maximums. Data for Little River indicate violations usually occur in late July/early September during the time period of interest for rearing (June 1 - September 14). Although it is unlikely that violations are occurring during the time period of interest for spawning (September 15 - May 31), data is currently not available to thoroughly assess this.

Section 303(d)(1) requires that Total Maximum Daily Loads (TMDLs) “be established at a level necessary to implement the applicable water quality standard with seasonal variations.” Both stream temperature and flow vary seasonally and from year to year in Little River. Water temperatures are cool during the winter months, and exceed the State standard between the summer months of June and September when stream flows are lowest and solar radiation is highest.

The USDA Forest Service (USFS) and Bureau of Land Management (BLM) have collected summertime stream temperature data throughout Little River between 1992 and 1999 (Figures 14 and 15). Since the period of record is short for all monitored sites, no trends or absolute conclusions are drawn from the data. Analysis of data collected from 1992 to 1999, reveals that 11 of the 17 monitored sites throughout the watershed frequently violated water quality standards for rearing temperature regardless of yearly variations in climate. Water temperature in mid to lower Cavitt Creek and Little River is typically in a degraded condition for much of the summer. For example, the first 11.2 miles of Little River had 7-day average daily maximum temperatures in the mid to upper 70’s for the past few years. Elsewhere in the basin, temperatures are not lethal, but they are high and result in stressful conditions for salmonids and other aquatic life that require cool water. The cumulative effects of even sub-lethal stress factors may reduce recruitment to successive life stages and eventually cause populations to decline.

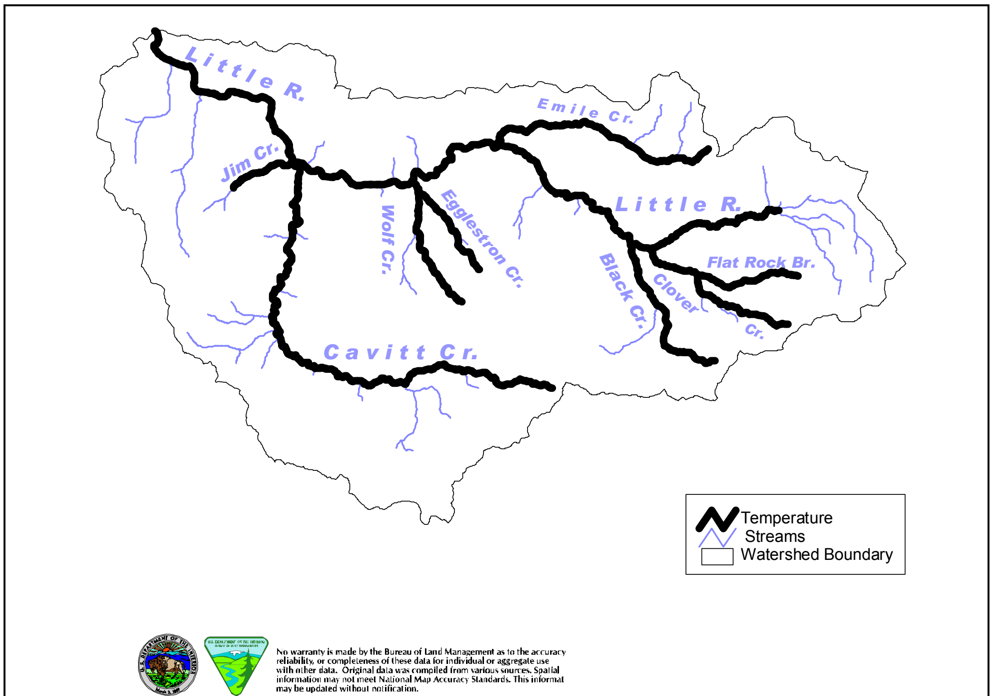

Figure 13: Little River segments currently listed for exceeding rearing temperature standards.

Based on data collected since 1994, stream temperatures in Little River and Cavitt Creek have exhibited much year-to-year variability in 7-day average daily maximums. Tributaries to Little River tend to have less variability. This is likely due to more streamside shade. The rate of stream heating that occurred in 1995 (considered a "normal" year for precipitation and temperatures) for main stem Little River from Clover Creek to White Creek was 0.5° F per mile, from White Creek to Cavitt it was 0.7° F, and from Cavitt Creek to the mouth of Little River it was 0.25° F (using 7-day average daily maximums).

Site Name	Period of Record	7-day ave. daily max. all years (F°)	Max. days over 64N (year)	Drainage area above temp. site (ac)
Cavitt Creek (mouth)	1994-1997	72.7	69 (1995)	32,157
Egglestron	1996, 98, 99	64.9	None	1,746
Emile	1996-1999	67.3	3 (1999)	1,220
Fall	1996-1999	61.2	None	5,526
Lower Jim	1994-1999	63.9	None	2,757
Upper Jim	1994, 1995	59.4	None	1,676
Little River (above Cavitt)	1994-1998	76.3	83 (1995)	76,558
Little River (mouth)	1994, 95, 97	78.1	75 (1995)	131,982
Little River (above Wolf)	1998, 99	73.8	56 (1999)	70,996
Rattlesnake	1999	63.0	1 (1999)	1,172
Wolf Creek (mouth)	1994, 1995	66.7	49 (1995)	5,774
Little River (Below Junction Cr.)	1994	61.6	None	8,859
Cultus Creek (mouth)	1995-1999	62.2	4 (1998)	5,364
Clover Creek (mouth)	1994-1999	67.7	60 (1998)	7,368
Little River (above Clover Cr.)	1995-1999	66.6	64 (1997)	14,949

Flat Rock Branch	1996-1999	64.8	45 (1998)	2,862
Little River (below White Cr.)	1994-1996, 1998, 1999	68.7	60 (1998)	37,632

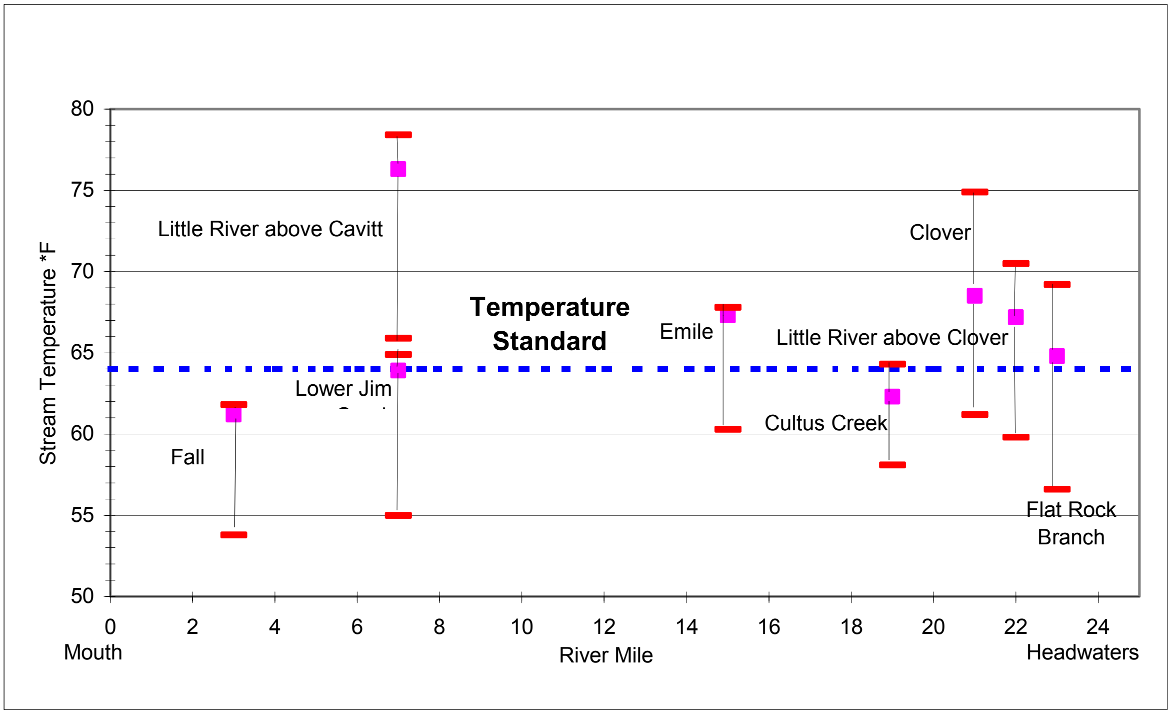

Figure 14. Little River Temperature Summary. June to September only (includes stations showing data meeting standards).

Figure 15. Graph of the moving (7) day average, as well as the range of daily maximums for temperature monitoring sites in the Little River watershed for 1996-1999. The mean is represented by the square. The range is depicted by the upper and lower bars. All displayed sites have a period of record of at least three continuous years. Cooler stream temperatures were encountered in 1995 and 1999 while 1994 temperatures were warmer.

Temperature Factor 1: Stream Shade

Stream temperature is influenced by riparian vegetation, stream morphology, hydrology, climate, and geographic location. While climate and geographic location are outside of human control, the condition of the riparian area, channel morphology and hydrology can be altered by land use activities. The elevated summertime stream temperatures measured throughout the Little River watershed result mainly from removal of riparian vegetation that compromises stream surface shading.

Stream temperature is driven by the interaction of many variables. Energy exchange may involve solar radiation, long wave radiation, evaporative heat transfer, convective heat transfer, conduction, and advection (e.g., Lee 1980, Beschta 1984). While interaction of these variables is complex, some are much more important than others (Beschta 1987). The principal source of heat energy for streams is solar energy striking the stream surface (Brown 1970). Exposure to direct solar radiation will often cause a dramatic increase in stream temperatures. Highly shaded streams often experience cooler stream temperatures due to reduced input of solar energy (Brown 1969, Beschta et al. 1987, Holaday 1992, Li et al. 1994). Stream surface shade is dependent on riparian vegetation type and condition. The ability of riparian vegetation to shade the stream throughout the day depends on vegetation height and the vegetation position relative to the stream. For a stream with a given surface area and stream flow, any increase in the amount of heat entering a stream from solar radiation will have a proportional increase in stream temperature.

Removal of riparian vegetation, and the shade it provides, contributes to elevated stream temperatures (Rishel et al. 1982, Brown 1983, Beschta et al. 1987). The condition of the riparian vegetation varies considerably in the Little River basin. The majority of the riparian vegetation is composed of narrow bands of hardwood and conifer species, where many if not all larger conifer trees have been removed. Such altered riparian areas are not sources of large woody debris and they lack the cool, moist microclimate that is characteristic of healthy riparian zones. These riparian corridors are not representative of the historical riparian condition. Based on 1946 and 1947 aerial photos of the basin, 72% to 88% of the historic riparian zones were late-seral, large conifers and hardwood stands (Little River Watershed Analysis 1995). Some spatial heterogeneity did exist in riparian vegetation due to primarily natural disturbance such as fire and blow down. Presently, only 30% of the riparian vegetation (based on NWFP ROD buffers) is considered late seral along fish-bearing streams in the basin (Little River Watershed Analysis 1995).

The shadow model (Park 1993) was used to estimate the existing shade in riparian areas for perennial (class 1,2,3) streams. Model parameters included active channel width, vegetative overhang, riparian tree height, shade density, and stream orientation. Active channel width and vegetative overhang were calculated based on stream orders and were derived from field-observations. Little River was divided into representative reaches based on stream orientation and riparian conditions. Existing shade values for perennial reaches were then calculated using the model. Target shade was determined from reference stream reaches that have riparian trees at site potential (average maximum height possible given site conditions). Years to full site potential represents the number of years to reach site potential tree height (and target shade). It may be affected by natural events.

Target shade values represent the maximum potential stream shade based on the site potential tree height. Riparian areas that reach target shade may or may not reduce stream temperatures below the Umpqua Basin stream temperature standard. Figure 16 displays the existing and target shade values for federal lands within the Little River watershed.

Riparian harvest has been a major contributor to shade reduction in the upper Little River watershed. Shade along the lower main stem has also been impacted by agriculture and human settlement. Natural processes that may elevate stream temperature include drought, fires, insect damage to riparian vegetation, diseased riparian vegetation, and blow down in riparian areas. The gain and loss of riparian vegetation by natural process will fluctuate within the range of natural variability. This WQRP focuses on human-caused disturbance that is under the control of the federal land management agencies.

Location	% Existing Shade	% Target Shade	% Shade Loss	Years to Full Site Potential
Hemlock Creek	87	91	- 4	45
Little River (above Hemlock Cr.)	87	91	- 4	35
Pinnacle Creek	80	89	- 9	75
Junction Creek	83	89	- 6	30
Little River Canyon	78	83	- 5	60
Emile Creek (below RM 4.8)	80	86	- 6	60
Emile Creek (above RM 4.8)	76	90	- 14	45
White Creek	84	90	- 6	45
Clover	87	88	- 1	15
Clover (Trib A)	85	91	- 6	35

Clover (Trib B)	86	91	- 5	35
Flat Rock Branch	90	91	- 1	10
Black Creek	80	90	- 10	50
Dutch	78	87	- 9	35
Cavitt Creek (above Withrow Cr.)	85	91	- 6	50
Cavitt Creek (below Withrow Cr.)	67	84	- 17	85
Cultus Creek	84	91	- 7	50
Plus Four Creek	84	91	- 7	40
Tuttle Creek	80	91	-11	70
Buckhorn Creek	64	88	-24	52
Fall Creek	63	90	-27	47
Rattlesnake	88	90	- 2	25
Engles	80	90	-10	30
Jim Creek	67	85[1]	-18	46
Bond	85	88	- 3	42
Greenman	71	88	-17	45
Wolf-Egglestron	77	89	-12	38

Figure 16. Current shade conditions and potential recovery for federal lands in Little River and its tributaries.

1. A large fire in 1987 affected the target shade calculations in Jim Creek.

Temperature Factor 2: Flow

The temperature change produced by a given amount of heat is inversely proportional to the volume of water heated (Brown 1983). A stream with less flow will heat up faster than a stream with more flow given all other channel and riparian characteristics are the same. Groundwater inflow tends to cool summertime stream temperatures and augment summertime flows. Reductions or elimination in groundwater inflow will have a warming effect on a stream.

The Little River watershed experiences extreme flow conditions typical of southwestern Cascade streams. Historical flows are a function of seasonal weather patterns: rain and snow in the winter months contribute to high flow volumes, while the summer dry season reduces flow, usually to 20 cfs at the Peel gauging station.

Water is withdrawn from Little River and tributaries, as well as nearby groundwater sources, primarily for domestic and irrigation uses. A total of 111 domestic water rights and 109 irrigation rights have been issued by the State of Oregon. Summer base flows in the lower reaches of Little River and Cavitt Creek are reduced by water withdrawals; however, the volume that is appropriated is very small. The Oregon Water Resources Department estimates that only 50% of consumptive rights are being utilized at any given time.

Irrigation	Agriculture	Domestic	Industrial	Municipal	Recreational	Miscellaneous	Total
9.86	0.05	1.24	0.36	0.00	0.11	0.28	11.90

Figure 17. Consumptive uses in cubic feet/second.

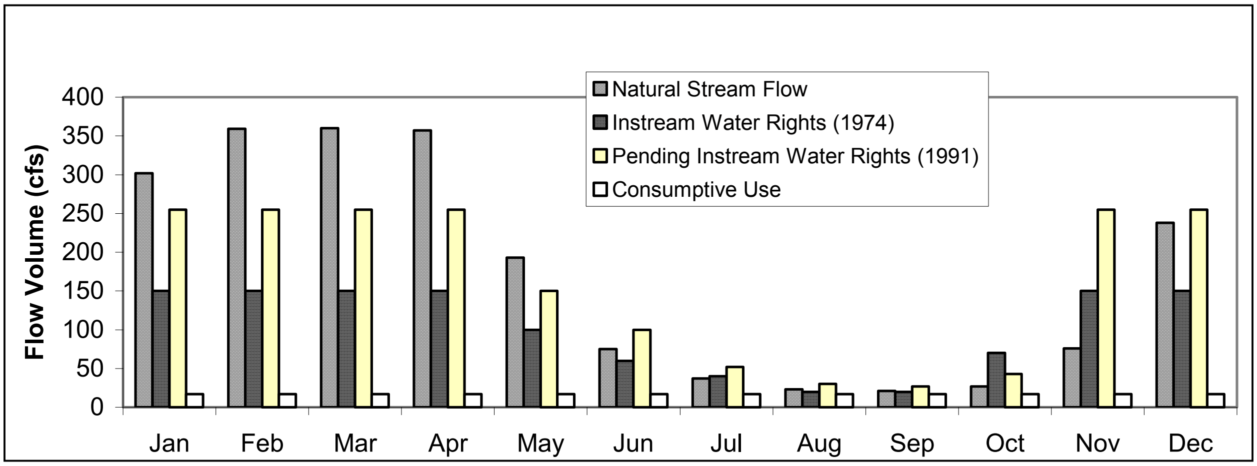

Figure 18. Natural stream flow at 80% exceedance level, in stream water rights (1974), pending in stream water rights (1991), and consumptive use occurring over one year at the mouth of Little River.

Appropriation of water is based on both water right seniority and water availability. As stream flows recede, those with junior rights are the first required to curtail use. Senior water right holders are allowed to continue using water, even in dry years and low flow conditions, as long as water is available to meet the demand under their priority date. Pending and issued in-stream water rights on Little River are based on flow requirements necessary to maintain fish habitat as determined by ODFW. The priority dates for the in-stream rights on Little River are 1974 and 1991. Because these rights are junior, the amount of consumptive use subject to regulation is very small. Even if all users were regulated off, it is unlikely the in-stream rights would be met during the dry summer months due to low total consumptive use and low seasonal stream flows.

New water rights for irrigation from Little River and tributaries are no longer being issued as natural stream flows are not sufficient to meet existing consumptive and in-stream rights during the irrigation season. Domestic rights may still be obtained if the applicant can demonstrate that surface water is the only available source for their use. The Oregon Water Resources Department (OWRD) and ODFW have identified the Little River watershed as high priority for stream flow restoration efforts under the Oregon Plan for Salmon and Watersheds (personal communication w/ Dave Williams, Water Master, Douglas County).

Temperature Factor 3: Stream Channel Morphology

While solar radiation and flow play a large role in determining stream temperature, stream channel morphology can also affect stream temperature. Streams that are narrow and have a high percentage of their streambed dominated by cobble and gravel are less prone to thermal loading than wide channels that are dominated by bedrock. Large wood plays an important role in creating stream channel morphology. Obstructions created by large wood help to settle out gravel. The deposition of gravel helps to decrease thermal loading by reducing the amount of water exposed to direct solar input, as a portion of the water will travel sub-gravel and not be exposed to sun. The removal of large wood has had a direct impact on stream channel morphology. Once the large wood was removed, the alluvial material held behind it washed out, causing channels to down-cut and eventually widen, allowing for increased thermal loading and stream heating. A more extensive discussion of stream morphology is included under the habitat modification parameter.

Management Actions

Narrow buffers (30 to 102 ft. wide), especially those providing direct shade over water, protect harvested forest streams from increases in temperature above their normal warming trends (Zwieniecki and Newton 1999). The Standards and Guidelines contained in the Northwest Forest Plan (NWFP) require riparian reserves along streams. Riparian Reserve widths are defined in the Aquatic Conservation Strategy (ACS) portion of the Standards and Guidelines. They are based on the site-potential tree height or a minimum slope distance, whichever is greatest unless described otherwise in a watershed analysis. Within these Reserves, timber harvest is prohibited except when catastrophic events result in degraded riparian conditions and salvage or fuel woodcutting would help attain ACS objectives. In addition, silvicultural practices to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics are to be applied when needed to achieve ACS objectives.

Under the NWFP, management actions which affect shade and therefore address the target loading allocation, include allowing riparian vegetation to grow to target shade values and using silvicultural practices where needed to meet ACS objectives. The watershed analysis recommends the following in Riparian Reserves:

Recommended treatment:

- Thinning in previously harvested riparian areas to enhance the growth of large conifers
- Thinning in older riparian stands that are unnaturally overstocked (due to fire suppression) to reduce the fire hazard and loss of ecological function
- Planting in under-stocked riparian areas to restore hardwood and conifer species

Focused on:

- Previously harvested, dense stands
- Unnaturally dense stands of mid- to late-seral trees along wide valley channels or steep ground that are at elevated risk of catastrophic fires and loss of ecological funtion
- Under-stocked stands that would provide the greatest benefit to streams with severe water temperature problems

C. pH

Introduction

The beneficial use affected by pH is resident fish & aquatic life and water contact recreation. The relevant Oregon water quality standard for the Umpqua Basin [OAR 340-41-0285 (2) (d)] is:

> *(A) Fresh waters (except Cascade lakes) and estuarine waters: pH values shall not fall outside the range of 6.5 to 8.5.*

A stream is listed as water quality limited if there is documentation that greater than 10 percent of the samples exceed standard and a minimum of at least two exceedences of the standard for a season of interest. The season of interest is summer, which is June 1 through September 30.

Many chemical and biological processes in a stream are affected by pH. The standard for pH values indicate the lower and upper limits that protect most aquatic species in western Oregon. Values outside of this range (within which salmonid fish species evolved) may result in toxic effects to resident fish and aquatic life (EPA 1986). When pH is outside this range, it can reduce the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. However, the effects of elevated pH on wild fish in a "natural" system have not been determined. The highest known documented juvenile steelhead trout densities on the Umpqua National Forest occur in a reach of stream with a pH as high as 8.9.

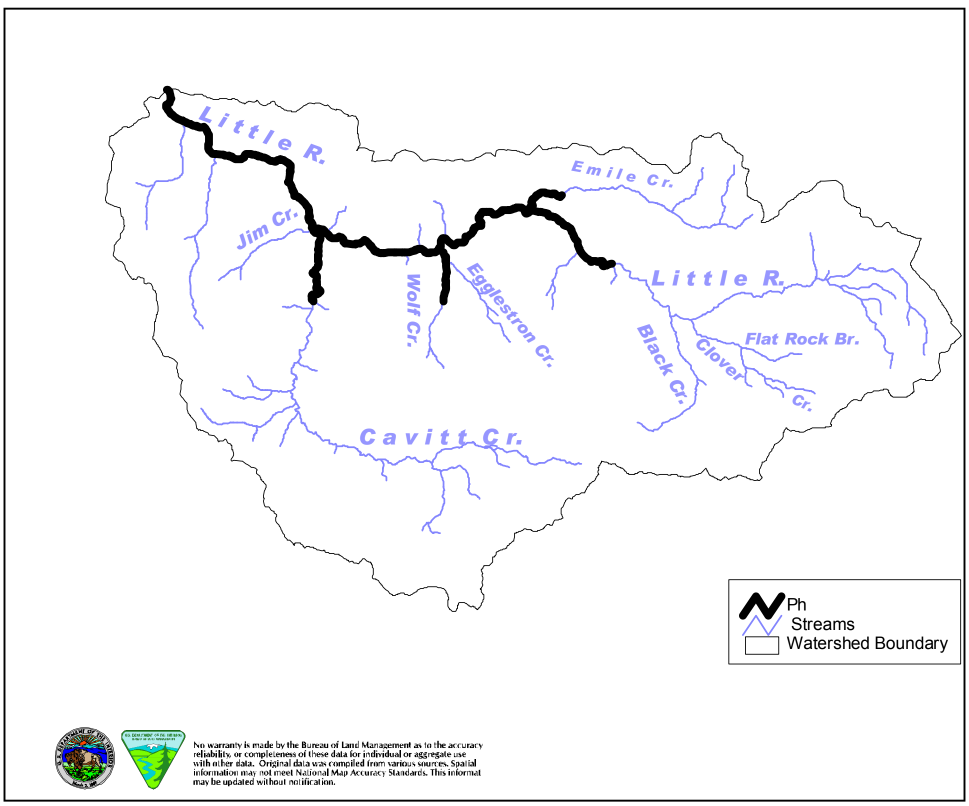

Figure 19. Little River segments currently listed for exceeding pH standard.

Existing Data

Single afternoon samples collected by US Geological Survey staff in Little River in July, 1995 found stream pH values near or above the water quality standards. Values of 8.1, 8.6, and 8.4 and 8.3 were measured near Black Creek, above Wolf Creek, and the mouth of the Little River, respectively (US Geological Survey Draft report 1996). The stream pH values recorded earlier in the day were well within water quality standards. Measurements taken for the Umpqua National Forest in August 1994, indicated afternoon pH levels exceeding numerical criteria in the lower 18 miles of the Little River main stem (Little River Watershed Analysis 1995).

Stream pH values are greatest in the afternoon, an indirect result caused by the consumption of carbon dioxide during photosynthesis (Stumm and Morgan 1981). Photosynthesis and aquatic plant growth follow yearly and diurnal cycles, which in Little River, are greatest during summer afternoons. The highest stream water pH values correspond to these periods of maximum photosynthesis. Conversely, pH values tend to be lower during the early morning hours and during the winter. Photosynthetic activity in dense algae mats can cause carbon depletion in the water column by taking up dissolved carbon dioxide faster than the atmosphere can replenish it. As carbon depletion progresses, there is an increase in pH as the equilibrium between dissolved carbon dioxide (CO_2), bicarbonate (HCO^-_3) and carbonate ions (CO_3^{-2}) moves towards carbonate.

Streams high in carbonates have a natural buffering capacity to dampen diurnal variations in pH attributable to photosynthesis and depletion of carbon dioxide. However, most western Oregon streams are low in alkalinity (carbonates) and many streams have pronounced diurnal pH swings. The US Geological Survey (1996) reported a single alkalinity value of 51 mg/l ($CaCO_3$) near the mouth of the Little River. Powell (1996) reported lower alkalinity at sites higher in the watershed (Powell and Rosso 1996). A median alkalinity value of 28 mg/l ($CaCO_3$) was reported by US Geological Survey (1996) for the North Umpqua basin.

Possible Causes of High pH

High summertime stream pH values in Little River probably result from algae growth due to the combined effects of the following:

1. Inadequate stream surface shading.
2. Increased nutrient inputs above background levels due to forest, agricultural, and residential land uses which may indirectly have an affect on pH (MacDonald et al 1991).
3. Increased channel scouring caused by increased peakflows from harvest units and roads.
4. A deficiency of large wood in the active channel.
5. Natural events and naturally occurring high pH values.

The availability of nutrients such as nitrogen and phosphorus can limit algae growth rates and photosynthesis. Inorganic nitrogen concentrations are very low in the North Umpqua River above the Little River confluence. US Geological Survey (1996) data indicate that inorganic nitrogen concentrations were undetectable (<5 ug/l) at most monitoring locations. In a single sample, collected near the mouth of Little River, ammonia and nitrate were below the levels of detection (<2 ug/l and 1 ug/l, respectively) (USGS 1996). Nitrogen is likely to be taken up by the algae immediately upon entry into the stream rather than to remain in the water column, therefore water column measurements may not accurately portray nitrogen concentrations. Total phosphorus and soluble reactive phosphorus concentrations were 7 ug/l and 1 ug/l, respectively. The US Geological Survey (1996) reported soluble reactive phosphorus concentrations were relatively plentiful elsewhere in the North Umpqua basin with median concentrations greater than 20 ug/l. Little River data and information collected elsewhere in the North Umpqua basin indicate that the availability of nitrogen highly affects the productivity of algae.

Elevated nutrient inputs from forest and agriculture land use, poorly sited or faulty septic systems, and sewage treatment system discharges promote primary production (algae growth) and elevated pH levels. Chemical fertilizers applied to commercial forest lands, agricultural areas and residential yards may be nonpoint sources of nutrients. While studies are currently underway, at this time no ambient data is available to definitively assess the affects of fertilizer application on water quality.

The Wolf Creek Conservation Center and the Christian Camp represent the only surface water point source discharges in the Little River watershed. There are several other potential sources, including failing *water pollution control facility* (WCPF) systems that do not discharge directly to surface waters.

Reduced stream surface shade has been shown to increase pH by encouraging photosynthetic chemical reactions associated with plant growth (DeNicola et al. 1992). Increased algal productivity in response to increased solar exposure has been well documented (Gregory et al. 1987, DeNicola et al. 1992).

High wintertime peak flows often scour streambeds, creating channel bottoms dominated by bedrock and/or large grained substrate, on which algae prefer to attach and grow. Bedrock stream reaches, commonly found in the Little River, provide favorable habitat and surface area for algae and poor habitat for algae eating aquatic insects. Ditches along roads that concentrate and funnel water to streams can increase peak flows.

Channel simplification may also promote algal growth and accumulations. Streamside harvest limits recruitment of large wood to the channel and floodplain. Powell (1996) suggests that poor woody debris recruitment can potentially increase pH. Large woody debris plays an important role in shaping stream channel complexity and bed form. Streams with a deficiency of large woody debris offer poor habitat for grazing macroinvertebrates that eat algae.

Natural processes that may elevate stream pH include floods, fires, insect damage to vegetation, diseased vegetation, and wind throw in riparian areas. These natural processes affect stream pH by increased nutrient loads delivered to the stream, increased solar exposure, and streambed scouring. Little River may also have naturally occurring high pH levels due to geology and the lack of connectivity between flood plain and riparian areas, which may affect the buffering capacity of riparian areas.

Management Actions

Due to the relationship of stream shade, large woody debris, and stream simplification to elevated pH values, restoration measures to address the temperature and sediment listings are also expected to improve elevated pH values. These include:

- Increased riparian vegetation growth to target shade values, which will reduce photosynthetic chemical reactions & algal productivity, and improve large wood recruitment.
- Reduction of sediment delivery to streams that will help improve channel complexity.
- Reduction of road effects on peak flows which will reduce streambed scour and alluvial erosion.
- Place large wood within tributaries and the main stem of Little River.

In addition, the watershed analysis recommends study of the effects of operational forest fertilization on pH. The Roseburg BLM has recently initiated several such studies. The first study is examining how fertilizer nutrients move through and affect the ecosystem. The second is examining the impacts to wildlife in terrestrial and aquatic riparian environments. The U.S. Geological Survey is conducting these studies.

D. Sediment

Introduction

For this parameter, the beneficial uses affected are: Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing. The relevant Oregon water quality standard for the Umpqua Basin [OAR 340-41-0285 (2) (j)] is:

> *The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed.*

A stream is listed as water quality limited if there is documentation that habitat conditions are a significant limitation to fish or other aquatic life as indicated by the following:

> *Beneficial uses are impaired. This documentation can consist of data on aquatic community status that shows aquatic communities (primarily macroinvertibrates) which are 60 % or less of the expected reference community for both multimetric scores and multivariate scores are considered impaired…*
>
> *-or-*
>
> *Where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity, or similar metric rating of poor or a significant departure from reference conditions.*
>
> *-or-*
>
> *Fishery data on escapement, redd counts, population survey, etc. that show fish species have declined due to water quality conditions; and documentation through a watershed analysis or other published report which summarizes the data and utilizes standard protocols, criteria and benchmarks. Measurements of cobble embeddedness or percent fines are considered under sedimentation. Documentation should indicate that there are conditions that are deleterious to fish or other aquatic life.*

The cumulative sediment impacts to fish and aquatic life from management activities appear to be widespread in the watershed. Little River was listed as Water Quality Limited for sediment based on information contained in the watershed analysis. This included aquatic insect assemblages, the early emergence of sac-fry from spawning gravels, and visible evidence of large amounts of fine sediment in spawning gravels. Increased sedimentation may cause sac-fry (larval fish) to emerge prematurely from the spawning gravels. Studies have shown that sac-fry are often forced out of gravel before they have absorbed their yolk sacs. Fine sediments fill the interstitial pore spaces of the redd, resulting in a lack of intergravel dissolved oxygen (Tappel and Bjornn 1993).

Loss of pool frequency and pool area may also result from sedimentation. Although it is difficult to directly link a particular sediment source with a specific pool, studies indicate excessive sedimentation may play a role in reducing pool depth and frequency (Lisle and Hilton, 1992).

Increased winter peak flows result in intensified water velocity in channels that erodes stream banks and modifies channel morphology. Exposure to the stresses of these exacerbated peak flows likely lowers over-winter survival of juvenile salmonids.

Aquatic insects are sensitive to changes in aquatic habitat and are often used to assess the quality of habitat conditions. Aquatic insects serve as the primary food source for fish and play an important role in stream ecology. The richness and variety of macroinvertibrate species is affected by excessive sedimentation because sediment may fill the interstices between coarser substrate and reduce available habitat.

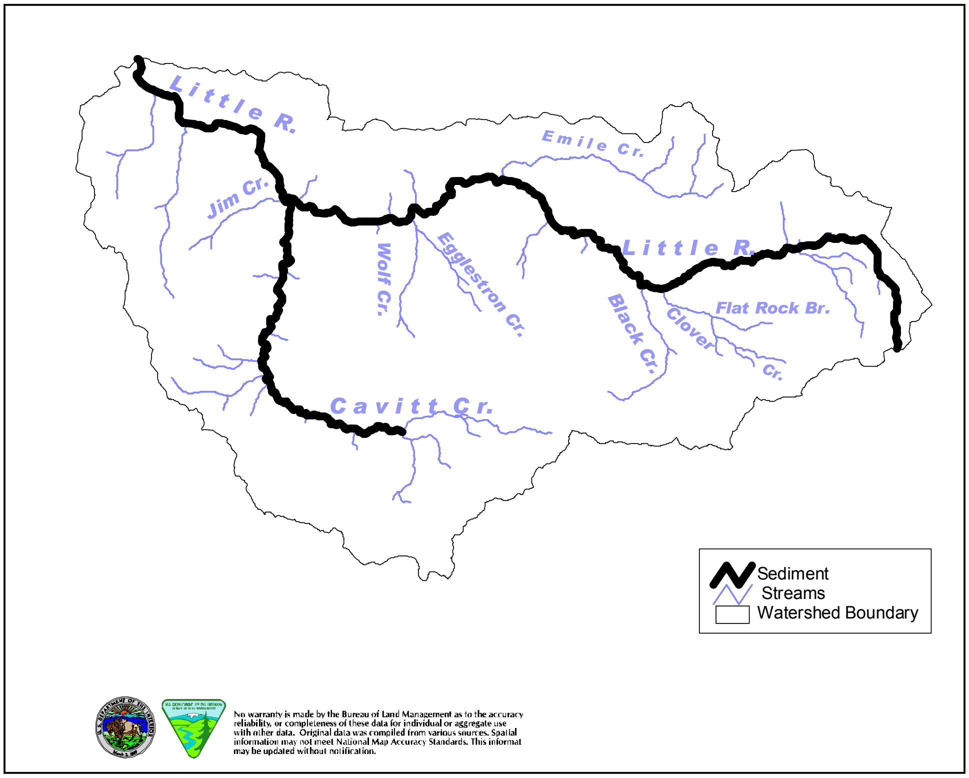

Figure 20. Little River stream segments currently listed for exceeding sediment standards.

Sediment Sources (Source Loading)

The Little River watershed lies within the North Umpqua sub-basin and drains portions of the Western Cascade Range, the Klamath Range and the Coast Range (Figure 21).

Much of the watershed lies within the Western Cascades geologic province (83%), while the Klamath and Coast Range geologic provinces account for 11% and 6% of the watershed, respectively (Little River Watershed Analysis 1995). The geomorphic processes of surface erosion, fluvial (stream-related), and landslides (mass wasting) are natural cyclic processes that strongly influence sediment production, and delivery in Little River. The mass movement of soil is a major component of hill slope erosion and sediment transport in streams in mountainous terrain. In steep areas, high precipitation events are more likely to trigger mass soil movements, which can introduce large pulses of sediment to stream channels (MacDonald et al, 1991). When landslides occur at a natural rate, they provide an important supply of gravel and large trees from upslope locations to lower order stream reaches. Landslides and bank erosion are the dominant sources of sediment in unmanaged systems (Norris, et al 1999).

Stream flows and sediment delivery are affected by the timing and intensity of rainfall delivery to streams. Sediment may be produced upslope of streams but may not be delivered until a large storm event occurs. High peak stream flows cause bank failures (mass wasting as a result of undercutting adjacent slope), entrenchment, and bed scour (Watershed Analysis 1995).

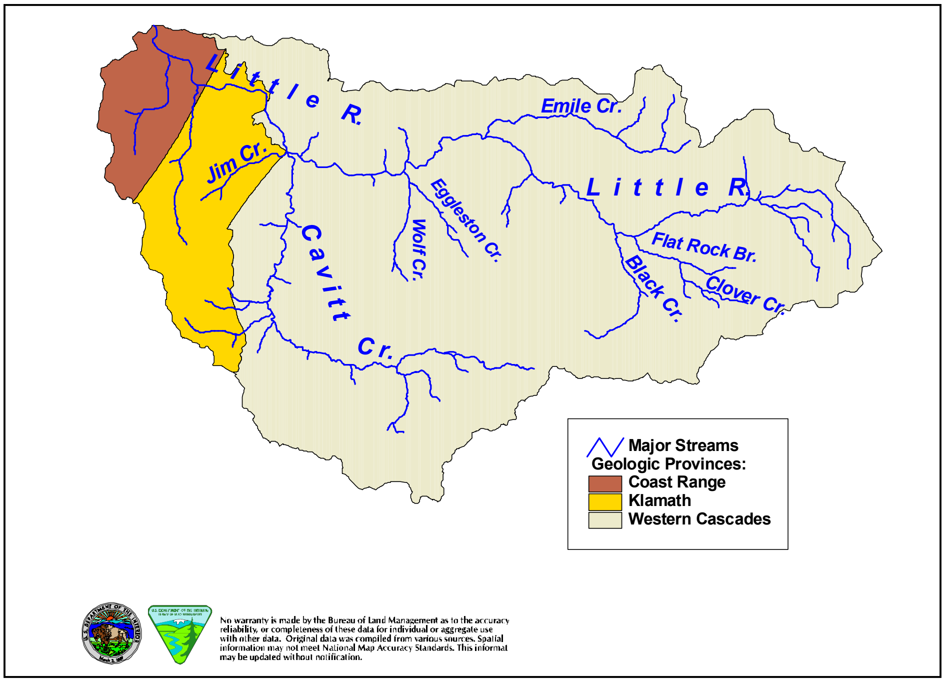

Figure 21. Geologic provinces in the Little River watershed.

Large wood in streams serves as an important storage mechanism for sediment. Over time, wood is delivered via chronic and episodic events to first- and second-order streams where it traps sediment. The buildup of wood and sediment continues until it is delivered downstream, through mass movement of the material (debris torrent) during large stream flow events. The material is then incorporated into the channel structure of larger streams where it becomes part of normal stream function (Norris et al 1999). In streams with extremely high sediment loads, the few areas of quality spawning gravels are often only found in association with these wood formations where the wood increases localized flow enough to flush clean an area of gravel (Watershed Analysis 1995).

Sediment is a natural part of stream systems and there is an equilibrium between sediment input, routing, and in-stream storage that needs to be maintained to have healthy stream systems. This means maintaining a balance between the amount of fine sediment, coarse bed load sediment and larger elements of in-stream structure (wood, boulders).

Sediment Budget

Management activities have affected this natural equilibrium by increasing sediment inputs and decreasing in-stream storage. A sediment budget provides a framework for categorizing sources of sediment and analyzing the effects of land use on sediment production and routing:

$$\text{sediment input} + \Delta \text{ in-stream sediment storage} = \text{sediment output}$$

Landslides, soil creep, and surface erosion contribute varying degrees to the overall inputs. Data from a study for the lower reach of the North Umpqua River (Stillwater Sciences 2000) provides an estimate of sediment loading. Uncertainties regarding this sediment budget result from a lack of data on the storage component, surface erosion, and deficiencies in the methodology of the landslide inventory used in the Little River watershed analysis.

Road surface erosion was estimated using SEDMODL and results indicate an average of 4.2 tons/mi²/yr. Surface erosion from harvest was estimated using GIS (page 31), but it is unlikely that much of this erosion is delivered to streams. Vegetative buffers are usually effective in filtering this erosion. Surface erosion is a relatively small portion of the total sediment budget.

A recent landslide study in the Tuttle and Engles Creek drainages was completed to address the deficiencies in the Stillwater Sciences analysis. Tuttle Creek represents a relatively unmanaged (or reference) setting and Engles Creek represents a managed setting. Although the area of analysis was significantly smaller (approximately 2 – 3 mi^2 vs. 560 mi^2), results indicate the average landslide area, volume, and mass as well as sediment delivery rates are significantly less than indicated in the Stillwater Sciences study.

Storage is the most poorly understood component of the sediment budget (Swanson et al 1982). Sediment storage and subsequent release by large wood removal may account for 20% of the increase in sedimentation rates above pre-management conditions (28.5 to 68.4 tons/mi²/yr) over a long-term period (Stillwater Sciences 2000). The Tuttle and Engles study inventoried the current distribution of large wood (LW) using the Forest Service Pacific Northwest Region protocol (2000). The associated sediment stored was an ocular estimation that place sediment volume in one of five categories. Tuttle Creek was identified as a "least disturbed" system with minimum riparian or large wood impacts from management activities. Engles Creek reflects management activities from the pre-stream cleanout and stream cleanout periods. Results of the study for Tuttle and Engles Creek are displayed in Figure 22 along with findings of Stillwater Sciences.

Storage & Sediment Parameters	Lower North Umpqua (Stillwater Sciences)	Tuttle Creek	Engles Creek
Stream order	3rd – 5th	3rd	3rd
Stream length (mile)	389	2.4	1.2
Average channel width (feet)	26	16	17
Number channel widths between LW sites (distance)	5 (130 ft)	3 (48 ft)	7 (119 ft)
Number of LW storage sites per mile [a]	41	110	44
Average sediment volume per active storage site [b] (ft^3)	1059	1012	338
Average sediment storage per length (ft^3/ft)	8	21	3

Figure 22. Large Wood and sediment storage for Lower North Umpqua, Tuttle, and Engles

[a] Large Wood storage sites occurring each mile: [(5280 ft/mi)/(ave. channel width)]/(number channel widths between LW sites)
[b] Not all storage sites inventoried had stored sediment; only those sites with stored sediment are included.

This study indicates that large wood storage sites occur twice as frequent in the selected "least disturbed" Tuttle Creek setting in comparison to Engles Creek. Stillwater Sciences' reference assumption described less frequent occurrence of large wood (every 130 feet). The average sediment storage forced by large wood was also found to be different for Tuttle and Engles creeks. The average volume of sediment stored per length of channel in Tuttle Creek was 7 times greater than Engles Creek and about 2.5 times greater than Stillwater Sciences' reference assumption. Although Stillwater Sciences estimated nearly similar volume of sediment per active storage site as found in Tuttle Creek,, there were less active sites identified (41 sites/mile) compared to Tuttle Creek (110 sites/mile).

Assuming that other managed lands in Little River watershed are similar to Engles Creek, the channels in these managed areas are storing only a third of the potential sediment at existing large wood sites in comparison to an less managed area, such as Tuttle Creek, and at about half the number of storage sites. In the long-term, the key to improving in-channel sediment storage is the growth of riparian trees. Where past management activities have replaced old growth riparian with younger stands, recruitment of large stable wood awaits the maturation (greater than 60 years [Grette 1985; Bilby and Wasserman 1989]). In the meantime, the legacy large wood in streams continues to decay and the associated storage of sediment declines (MacDonald 1991).

An output rate of 1339 tons/mi²/yr was calculated from stream gauge flows and turbidity measurements for Steamboat Creek from 1957-1996. Steamboat Creek is similar geomorphically to Little River although it appears to route flow more efficiently than Little River during flood events (USFS open file report 93-63 1993). This output is approximately 4 times that of the reference condition.

Figure 23 provides a summary of Stillwater Sciences sediment budget for the Lower sub-basin reach of the North Umpqua River and a sediment budget based on the landslide study in the Tuttle and Engles Creek drainages. Due to limited field verification, considerable uncertainty is associated with these figures. A rough estimate of the error range is ±50% (Stillwater Sciences 2000).

	Lower North Umpqua (Stillwater Sciences)		Engles and Tuttle Creek Landslide Study	
Sediment Budget	**Reference Condition (tons/mi.^{2}/yr)**	**Current Condition (tons/mi.^{2}/yr)**	**Reference Condition (Tuttle) (tons/mi.^{2}/yr)**	**Current Condition (Engles) (tons/mi.^{2}/yr)**
Input				
Landslides [a]	171[b]	798[b]	48[c]	430[d]
Soil Creep[e]	71	71	71[f]	71[f]
Surface Erosion	14[g]	Unknown	14 [g]	18[h]
Total Inputs	256	869	133	519
Output	285[g]	1339[i]	Unknown	Unknown
Storage Change	0[j]	(57)	0[j]	Unknown[k]

Figure 23. Sediment budgets for Lower North Umpqua and the Engles & Tuttle drainages.

[a]Landslide sediment inputs include rapid-shallow slope failures (including debris flows) that originate in colluvial hollows, as well as from slumps, and active toe zones of earth flows.
[b]This value is the average of sediment delivery rates based on landslide inventories in the Upper Steamboat basins and the Little River AMA watershed analysis (using 1946 photos).
[c]Current condition in Tuttle Creek, a reference drainage in Little River (with a small landslide dataset of recent features and assumption of 25 year frequency).
[d]Current conditions in Engles Creek (~2-3 mi²), a managed drainage in Little River, is based on a small landslide dataset and the assumption of a 3-year frequency of landslides observed. The landslide data are dominated by a debris flow feature initiated by road drainage in a recent clearcut. The frequency of the coincident events of storm flows and the harvest/road drainage features observed in Engles Creek is unknown.
[e]Sediment inputs from creep are assumed to be the same for reference and current conditions.
[f]Soil creep was not analyzed, these numbers are from the Lower North Umpqua sediment budget (Stillwater Sciences 2000).
[g]From studies conducted by Swanson et al (1982) in the H.J. Andrews Experimental Forest, Oregon (Western Cascades lithography).
[h]Road surface erosion was estimated using SEDMODL and results indicate approximately 4.2 tons/mi²/yr.
[i](McBain and Trush 1998).
[j]Based on an assumption of long term equilibrium between inputs and outputs (i.e. no long-term net aggradation of degradation).
[k]See figure 22 for comparison of sediment storage for Tuttle and Engles Creek by stream length (ft^3/ft).

The sediment budget equation inequalities these data imply (inputs plus storage changes not equal to output) probably result from a lack of understanding of the storage component and deficiencies in the methodology of the landslide inventory used in the little River watershed analysis. A particular deficiency is in the quantity of the inner gorge landslides that are overlooked by an aerial photo inventory.

The sediment budget is indicative of general patterns of geomorphic processes and provides rough estimates of changes in the magnitude of sediment process rates. This data indicates that current sediment inputs are up to four times that of the reference condition and are likely due to extensive and intensive management activities in the watershed. Landslides accounted for 36 – 66% of the overall sediment budget in the reference condition and 83 - 92% of the overall sediment budget in the current condition.

Geomorphic Land Types as a Framework for Analysis
The geology and soils of an area are major determinants of hill slope susceptibility to landslides. Geologic parent materials are an important determinant affecting not only total sediment production but also the size of sediment particles from forested watersheds (Reiter and Beschta 1995). A land type map was created to help further assess sediment production and delivery (Figure 25). This map uses geology, geomorphology, and slope to derive land types that vary in their potential for erosion and mass wasting. The three high-risk geomorphic land types in Little River are:

1. Klamath Mountain Granitics – Residually weathered granitic rocks on steep-gradient, highly dissected hill slopes; episodic source of coarse-textured sediment flux via surface erosion and rapid-shallow landsliding.
2. Western Cascades Volcanics – Residually weathered lava flows and tuffaceous rocks on steep-gradient, highly dissected hill slopes; episodic source of coarse-textured sediment flux via rapid-shallow landsliding.
3. Landslide-Earthflow Complex (LS) – Unconsolidated mass wasting deposits forming large complexes in gentle- to moderate-gradient, weakly dissected terrain; chronic source of fine-textured sediment flux by fluvial erosion and slow, deeper landsliding.

The valley inner gorges on the steepest ground that abuts stream corridors (steep streams) represent the most sensitive (highest risk) landform for erosion within the three geomorphic land types described above. The deep, finer textured soils typical of landslide-earthflow complex are susceptible to stream down cutting and bank erosion (Watershed Analysis 1995). These areas are highly susceptible to accelerated detrimental (fine) sediment production caused by management activities.

Management-related (Controllable) Sediment
Natural sediment delivery processes occur and vary spatially and temporally depending on precipitation and land types. These processes deliver both beneficial (gravelly, coarse) and detrimental (fine, silty) sediment to streams. This WQRP focuses on controllable sources of sediment input & storage. Federal management-related actions that contribute to accelerated sediment production, delivery, and storage were analyzed to (1) provide a quantitative and/or qualitative assessment of management-related sediment production and delivery; and (2) target restoration where it will be most beneficial.

Roads
The road transportation network is an important influence on sediment production and delivery. In addition to the effects of land types, road density/use/design/location can be important in affecting

the extent and magnitude of road-related sediment impacts (Reiter et al 1995). King and Tennyson (1984) observed altered hydrology when roads constituted more than 4% of the catchment area. This correlates to approximately 4 miles per square mile of area. Other studies evaluating storm response to road construction range up to 15% of the area in roads. Results are extremely variable because the effects of roads are not well defined and are difficult to detect, especially as the size of flood increases (Grant, Megahan, and Thomas 1999). Road densities in Little River watershed are relatively high and fairly evenly distributed (Figure 24). There are 954 miles of roads distributed over 206 square miles for an average density of 4.6 Mi/Mi^2. Road densities in the high-risk geomorphic land types are 5.1 in Landslide-Earthflow, 4.5 in Klamath Granitics, and 4.3 in Western Cascades Volcanics.

	Sub-watershed												
	Black Creek	Clover Creek	Cultus Creek	Emile Creek	Little River Canyon	Lower Cavitt Creek	Middle Cavitt Creek	Middle Little River	Red Butte	Upper Cavitt Creek	Upper Little River	Watson Mtn	Wolf Creek
Road Density (mi/mi^2)	4.9	3.7	4.5	4.0	4.3	4.8	5.3	4.9	4.4	5.0	4.4	4.7	4.5

Figure 24. Road densities (for all roads in the Little River watershed).

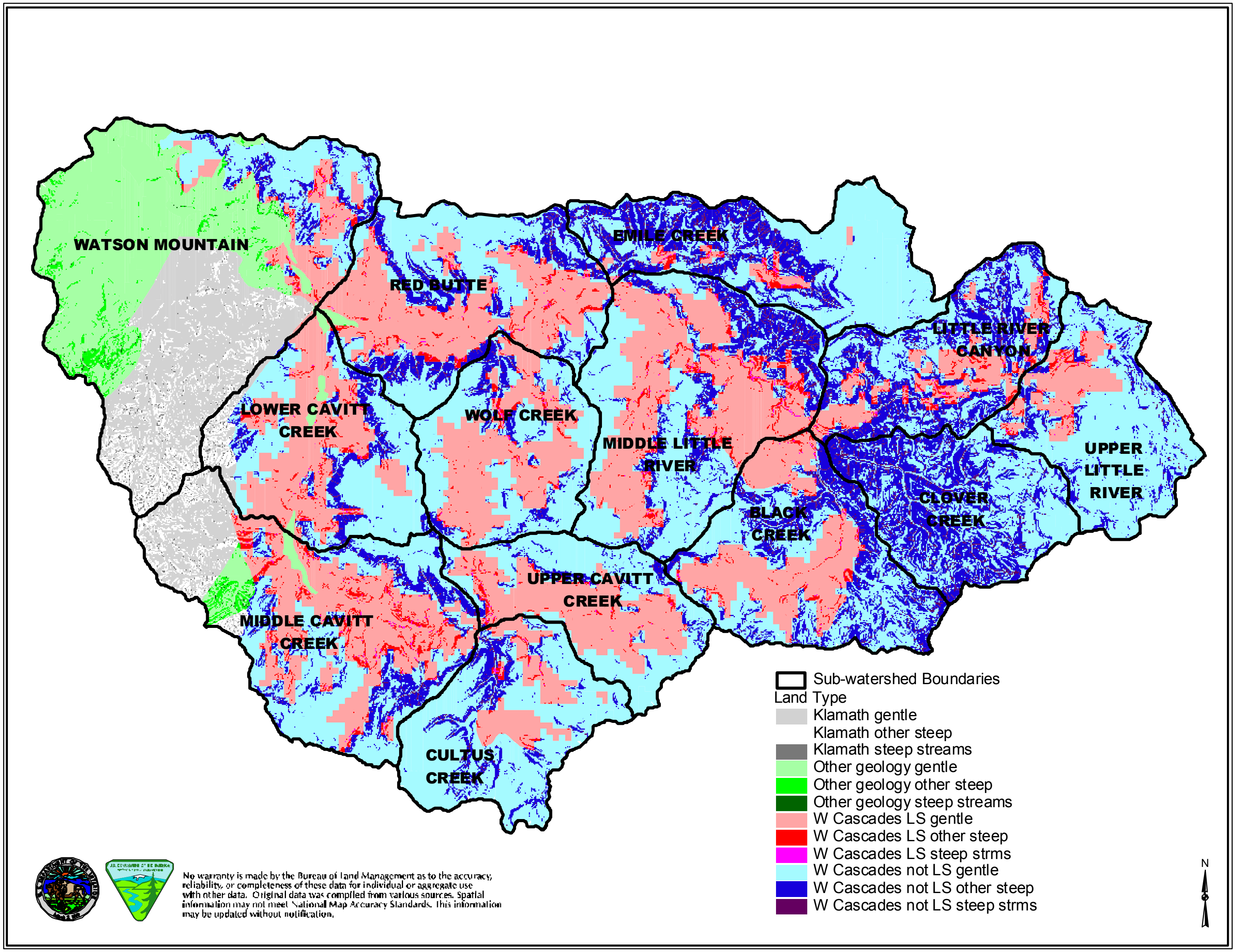
WATSON MOUNTAIN
RED BUTTE
EMILE CREEK
LITTLE RIVER CANYON
LOWER CAVITT CREEK
WOLF CREEK
MIDDLE LITTLE RIVER
UPPER LITTLE RIVER
CLOVER CREEK
BLACK CREEK
UPPER CAVITT CREEK
MIDDLE CAVITT CREEK
CULTUS CREEK
Sub-watershed Boundaries
Land Type
Klamath gentle
Klamath other steep
Klamath steep streams
Other geology gentle
Other geology other steep
Other geology steep streams
W Cascades LS gentle
W Cascades LS other steep
W Cascades LS steep strms
W Cascades not LS gentle
W Cascades not LS other steep
W Cascades not LS steep strms
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data was compiled from various sources. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.
N

Figure 25. Land types in the Little River watershed.

Native road surfaces, road cuts & fill slopes, and ditches represent potentially exposed surfaces subject to surface erosion and mass wasting. Subsurface flow may be partially intercepted along road cuts and transferred into a more rapid runoff via ditches causing increased peak flows and mass wasting. Failed road/stream crossings and stream channel diversion pose a risk for severe sedimentation and mass wasting.

Ditches

Ditch lines along roads collect water that is drained from the road surface and cut slopes. When ditches flow into streams (effectively serving as an extension of the stream network), water is delivered more quickly than in unroaded situations thereby accelerating peak flows. Roads can act to concentrate run-off and divert natural flow patterns and potentially causing mass wasting. Data collected for a 1995 road/stream-crossing inventory of federally managed roads in Little River shows the average ditch length at stream crossings is 337 feet. Ditch length is the distance of ditch line that flows water into a stream. It is measured from the point it spills into a stream to the nearest culvert or cross drain. Figure 26 shows the number and length of ditches at stream crossings for federally managed roads in Little River. The key to reducing the effects of ditches on sediment delivery is to reduce the length of the road drainage ditch that leads directly to the point where it discharges into the channel (Norris et al 1999). Restoration would involve installing cross drains to shorten ditch lengths and disperse water away from the point it enters a stream.

Sub-watershed	Number of Ditches			
	< 300’	=> 300’ & < 600’	=> 600’ & < 900’	=> 900’
Black Creek	21	22	21	19
Clover Creek	25	11	6	3
Cultus Creek	35	19	12	1
Emile Creek	41	29	12	12
Little River Canyon	49	37	15	7
Lower Cavitt Creek	54	0	1	0
Middle Cavitt Creek	48	1	2	1
Middle Little River	45	43	16	31
Red Butte	38	19	9	5
Upper Cavitt Creek	97	0	0	0
Upper Little River	37	39	7	11
Watson Mountain	40	11	3	7
Wolf Creek	73	2	4	3
Totals	603	233	108	100

Figure 26. Number and length of road ditches for federally managed roads in Little River. The longer the
ditch, the more potentially detrimental it is.

Stream Crossings

Stream crossings are the places where roads intersect streams. A drainage structure is normally installed to allow vehicle passage. In most cases, this structure consists of a culvert with soil and rock around it. Culverts can constrict the natural flow of water and restrict the normal transport of sediment and debris. When culverts become plugged and dam water, they can cause fills to become saturated, leading to failure. Plugged culverts can cause water to rise up into the road prism and spill into ditches where it is diverted to another stream. The road/stream-crossing inventory for federally managed roads in Little River was re-evaluated for this analysis to determine (1) water diversion potential and (2) the risk and consequence of road/stream crossing failure (Figure 27). Road/stream crossings were rated from 1 (low) to 5 (high) based on the risk of failure and the consequence (sediment delivery) of the failure. Bridges and other sites (such as low water fords) that had missing data germane to the assessment were not given a rating.

Restoration of stream crossings would eliminate water diversion potential and reduce the risk of failure. It includes redesigning, installing, or maintaining drainage structures and stabilizing road fills around drainage structure. All culverts should be sized to pass a 100-year flood and associated sediment and debris. Some of the information collected for the 1995 inventory was based on a subjective evaluation of conditions. A thorough site analysis will be needed during project level planning to verify the need for restoration.

Sub-watershed	Risk and Consequence of Failure (Number of Crossings by Risk Class)					Water Diversion Potential (Number of Crossings)	
	1	2	3	4	5	Yes	No
Black Creek	2	5	44	12	9	45	38
Clover Creek	8	7	15	5	3	20	25
Cultus Creek	8	17	24	9	4	28	39
Emile Creek	14	25	38	5	2	50	44
Little River Canyon	11	14	55	19	8	81	29
Lower Cavitt Creek	1	3	40	5	3	35	20
Middle Cavitt Creek	5	7	23	8	5	34	18
Middle Little River	7	21	57	34	8	78	58
Red Butte	10	15	35	8	1	48	23
Upper Cavitt Creek	8	21	43	13	6	61	37
Upper Little River	6	16	33	20	8	41	53
Watson Mountain	7	10	24	5	4	39	22
Wolf Creek	4	12	46	13	7	53	29
Totals	*91*	*173*	*477*	*156*	*68*	*613*	*435*

Figure 27. Road/stream crossings risk and consequence of failure and water diversion potential for federally managed roads in the Little River watershed. Those rated 5 have the highest risk of failure and the highest consequence of failure (only stream crossings with a culvert were given a rating). As an example, Black Creek has 2 crossings rated as a 1, 5 crossings rated as a 2, and so forth. A total of 68 crossings were rated as a 5. Water diversion potential is the likelihood high water will be diverted down a ditch into another stream.

Road Prism

Roads have the greatest potential for hydrologic effects where they parallel streams, particularly where road fills have been placed in the flood plain (BLM 2000). In valley bottoms, roads can affect stream morphology by hardening stream banks and constricting streams during high flows. On hill slopes, road fills and cut slopes that become saturated with water can fail and deliver sediment to streams. Surface erosion from inadequate (native) surfaces, rutting, and lack of cross drains is more likely to be delivered to streams when a road is close to a stream and there is little vegetative buffer. Analysis of sediment delivery due to surface erosion from federally managed roads was accomplished using SEDMODL. The model considers roads that are within 200 feet of a stream and generally identifies more delivering road segments than actually exist on the ground. The model uses elevation, road data[2], road cut slope condition, stream location, precipitation, geology, and soils information. Figure 28 shows the estimated surface erosion delivery in each sub-watershed along with the miles of road segments rated as medium or high sediment deliverers in landslide-earthflow complex. Those segments rated as medium or high deliverers that fall within landslide-earthflow complex areas are most likely to accelerate detrimental (fine) sediment delivery to streams. The watershed analysis found that the Cavitt Creek and Wolf Creek/Middle Little River areas are the areas of highest priority for transportation assessment and planning efforts.

[2] SEDMODL is designed to run with road locations only or with the additional attribute information of surface/use/width. Runs of the model with attribute information on actual road conditions provide more reliable model results and can be used to examine the relative relationships between different values of sediment delivery or as a good indicator of actual sediment inputs. This information is available for federally managed roads in the Little River watershed and was used in the model. Stream location data that was used is the best that is currently available, however, there may be more ephemeral streams on the ground than are represented in GIS.

According to Luce and Black (1999) road-related surface erosion appears to be concentrated in the first few years after construction. Landslide-related erosion could occur many years later, and is highly episodic. Wemple et al (1999) found that fill slope slides were the dominant process of sediment production from roads. An analysis of several miles of road in the Watson Mountain sub-watershed showed sediment production from road cut and fill slope mass wasting was 12 –16 times that of surface erosion. The watershed analysis found that in general, roads located on slopes in excess of 60% slope and within 200 feet of streams have the greatest potential to deliver landslide-generated sediment to streams. All roads should have surface and drainage facilities or structures that are appropriate to their patterns and intensity of use. A study of roads in western Oregon found that variability in sediment production from road segment to road segment is high. Most segments produce little sediment, while only a few produce a great deal. It is possible to substantially reduce road erosion by targeting those sections with the greatest sediment production (Luce and Black 1999). Restoration efforts would include road treatments (installing drain dips, adding road surfacing material, repairing ruts, stabilizing road cuts and fills on slopes >60%) and road decommissioning. The SEDMODL provides an indication of relative road surface erosion and likely problem areas that will require a more detailed review to verify the need for restoration. Future roads should not be located in steep inner gorge or unstable headwall areas except where alternatives are unavailable (Redwood Creek TMDL 1998).

Sub-watershed	Total Erosion (tons/year)	Average Erosion Rate (tons/mi^2/year)	Miles of Medium/High Sediment Delivering Segments in Landslide Complex Areas
Black Creek	51	3.4	6.4
Clover Creek	23	2.0	0.0
Cultus Creek	51	4.2	1.7
Emile Creek	23	1.7	0.4
Little River Canyon	82	6.8	3.8
Lower Cavitt Creek	83	5.9	4.6
Middle Cavitt Creek	69	3.1	2.7
Middle Little River	43	2.1	4.2
Red Butte	93	5.5	3.7
Upper Cavitt Creek	86	8.1	5.2
Upper Little River	54	4.6	1.9
Watson Mountain	100	2.9	0.7
Wolf Creek	53	4.5	4.2
Totals	*811*	*4.2*	*39.5*

Figure 28. Estimated surface sediment delivery from federally managed roads in the Little River watershed. Model uses road attributes showing a breakdown of road surface and use. If model is run without this attribute information (instead using the defaults of gravel surface and light use), the total amount of sediment is 346 tons.

Timber Harvest

Timber harvest that exposes mineral soil can accelerate mass wasting (land slides) and surface erosion. Lack of forest canopy can increase rain-on-snow event peak flows leading to increased fluvial erosion. Harvest also affects (particularly when harvest occurs in riparian areas) the amount and size of woody debris that reaches streams. Woody debris increases stream habitat complexity and serves as a storage mechanism for sediment. Beneficial sediment (gravel and cobble) serves as fish spawning habitat.

<u>Peak Flows and Bank Erosion</u>

The large channel-forming runoff events in the Little River Watershed occur during the winter during rain-on-snow events. A common conclusion of the research on this type of runoff event has been that statistically significant peak flow increases are associated with canopy removal and roads in smaller drainages (Jones and Grant, 1996; Thomas and Megahan, 1998; Jones, 2000). The loss of canopy influences snow accumulation and melt rates. Hydrologic recovery of the canopy occurs as vegetation is re-established and may require up to 40 years (Harr and Coffin 1992) for full recovery. Hydrologic recovery has been described as including a canopy closure of 70% with an average tree diameter of 8 inches (Christner, 1982). In the absence of a recovered canopy, water input to soils is greater from increased snow accumulation and melt rate. Higher amounts of water input for the same climatic event shifts the frequency of occurrence of water input to a shorter recurrence interval. This can influence stream flows and bank erosion (Harr 1981, Harr and Coffin 1992).

As less total Federal acreage is managed in the future under the Northwest Forest Plan, hydrologic conditions in forest stands will improve in the upper areas of the watershed where Federal ownership is blocked-up and mostly contiguous. The influence of canopy on rain-on-snow events will generally diminish over time. Elsewhere in the watershed where federal lands do not occupy most of a natural drainage, the trend is not known.

A qualitative peak flow approach was adapted from the Augusta Creek Study on the Willamette National Forest (Cissel et al, 1998) to address potential bank erosion. The potential susceptibility to rain-on-snow peak flows was evaluated across the watershed by assessing likely snow accumulation and melt along with the storage of ground water. Snow accumulation is a function of elevation and is grouped into elevation zones. Snowmelt is grouped by aspect with the highest melt rates for south- and west-facing slopes. Soil depth was used to assess ground water storage and was interpreted from soil inventory data. Elevation zones, aspects, and soil depths were merged into a single GIS map to identify areas of High/Moderate/Low susceptibility to peak flows from rain-on-snow events. Figure 29 shows this potential condition for Little River Watershed.

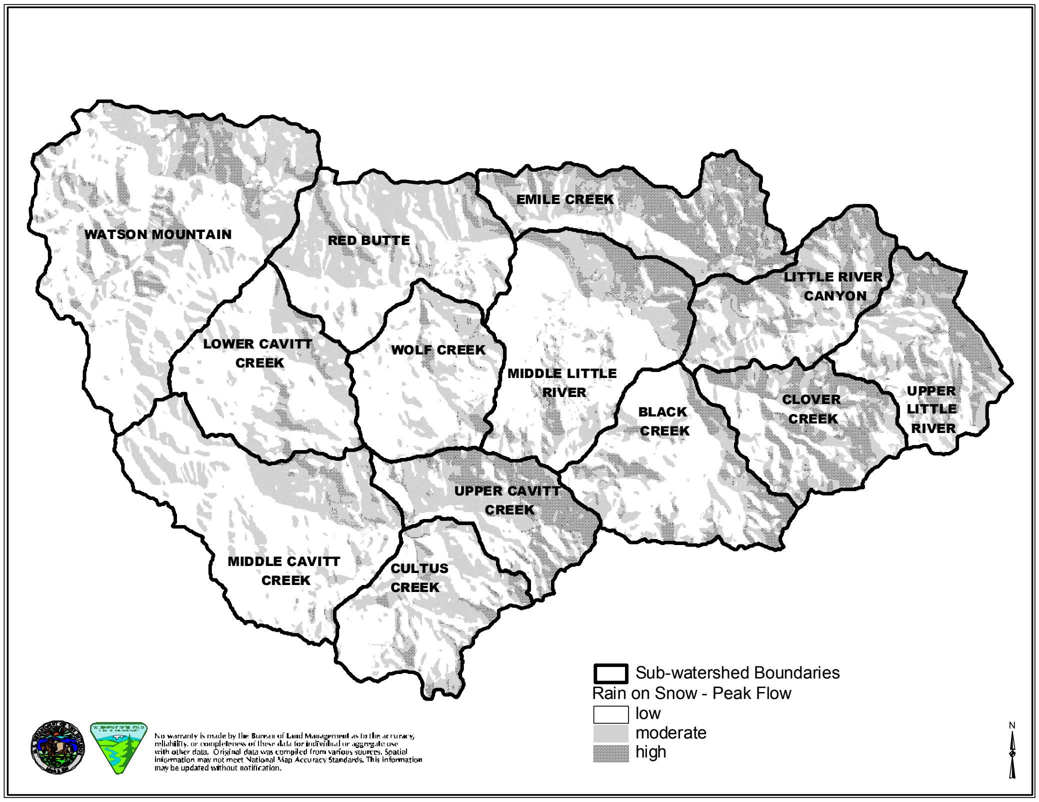

Figure 29. Potential susceptibility to rain-on-snow peak flows events in Little River.

The higher risk runoff areas in the Little River Watershed were then combined with GIS information showing forest stands that are not hydrologically recovered (stands less than 40 years old). The results identified those areas that have a higher risk of naturally augmented rain-on-snow runoff and that are likely hydrologically unrecovered. The deep, finer textured soils of the landslide-earthflow complex are highly susceptible to stream down cutting and bank erosion. Areas of high susceptibility to rain-on-snow peak flows and low hydrologic recovery that are upslope and contribute to streams in landslide-earthflow terrain would potentially have the greatest influence on bank erosion. Figure 30 provides an indication of places where additional harvest and associated roads would have the most impact on bank erosion. This graphic represents current conditions only. As both management and recovery occur, this information will change.

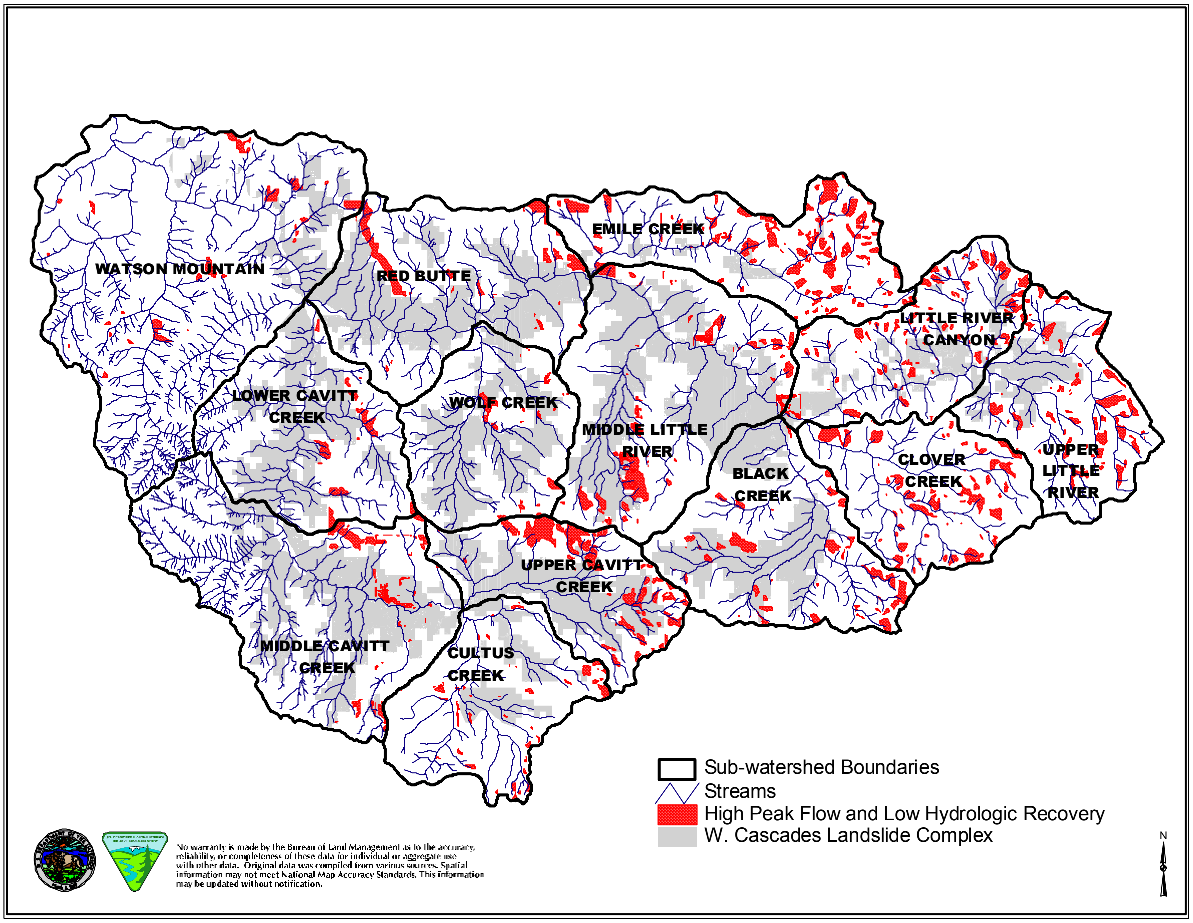

Figure 30. Bank erosion susceptibility in Little River. Additional harvest would likely have the most impact on bank erosion in areas with high susceptibility to rain-on-snow peak flows and low hydrologic recovery that flow into landslide complex terrain.

Surface Erosion

Timber removal due to harvest can cause surface erosion and sediment delivery to streams. Accelerated sediment production and delivery occurs when bare soil is exposed to heavy rainfall and the runoff reaches streams. Ground-based harvest methods can compact soils. This reduces the soil's ability to absorb water (Watershed Analysis 1995) and can lead to more overland flow of water. Generally, the accelerated surface erosion dissipates when vegetative cover is established. Only slight suspended sediment increases (excluding landslides) were found for two years following clearcut harvest in a western Oregon Cascades watershed (Reiter and Beschta 1985). Studies have shown that non-channelized (surface) transport of sediment decreases as slope decreases and the number of obstructions increases within a filter strip. Vegetation buffer strips on the order of 200 feet are generally effective in controlling sediment that is not channelized (Belt, et al 1992, FEMAT 1993). The Northwest Forest Plan provides valuable riparian vegetative filters for capturing and holding sediment from hill slope surface erosion.

Mass Wasting

Landslides can be triggered by timber harvest due to a loss of tree root strength and increased soil saturation from reduced tree canopy. Studies in Oregon and Washington generally indicate that the harvesting of trees increases the rate of mass failures by 2 to 4 times over that experienced on uncut areas (Reiter and Beschta 1995, Norris et al 1999). A landslide study by the Oregon Department of Forestry (ODF) in the Coast Range following the major storms of 1995-1996 found that the general pattern is that the rate of land sliding was highest in stands 0-9 years post harvest, and lowest in stands 10 to 100 years. They further determined that landform and slope steepness are tied to landslides rates. They found that 100% of landslides occurred on slopes > 40%, 92% of landslides occurred on slopes over 60%, and concave slopes had the greatest incidence of landslides. One-third to one-half of all landslides in the Oregon Coast Range originated in headwall areas (ODF 1998). The SINMAP model (Pack, Tarboton, and Goodwin 1998) was used to create a slope stability index map. The model uses slope and a topographic wetness index to predict slope stability. The model showed that generally, the most unstable areas are steep inner gorges (over 45% slope) and headwalls.

The watershed analysis and a study by Stillwater Sciences (2000) in the lower portion of the North Umpqua River indicates that the number of landslides has dramatically increased with the advent of management activities in the Little River watershed. Future clearcut and/or ground-based harvest should be avoided in steep inner gorge, unstable, or streamside areas unless a detailed assessment is performed which shows there is no potential for increased sediment delivery to streams as a result.

Large Woody Debris

Large woody debris is an important mechanism for the storage and slow release of sediment over time. This includes the beneficial gravel and cobble for spawning and aquatic insect production. Trees that fall into streams usually come from within 30 meters (98 ft.) of the channel edge; 70 to 90 percent of the large wood in streams is derived from this distance (Norris et al 1999). The total amount of wood in the streams may not change with timber harvest, but the size of the wood is reduced (Norris et al 1999). Today, roughly 30 percent of riparian stands along fish-bearing streams in the watershed are considered to have late seral characteristics (Watershed Analysis 1995). Figure 31 shows percent of total riparian area (using NWFP riparian reserve widths) that has been harvested since 1946.

Protection of streamside zones by leaving vegetation intact will help maintain the integrity of channels and preserve important terrestrial-aquatic interactions (Hicks et al 1991). The NWFP Standards and Guidelines provide for riparian reserves along streams. These reserves will provide a future source of large woody debris for streams. In addition, re-introducing fire into the ecosystem could provide a source of wood for streams.

	Sub-watershed												
	Black Creek	Clover Creek	Cultus Creek	Emile Creek	Little River Canyon	Lower Cavitt Creek	Middle Cavitt Creek	Middle Little River	Red Butte	Upper Cavitt Creek	Upper Little River	Watson Mtn	Wolf Creek
% Harvest in Rip. Areas	42	22	26	43	32	69	88	62	57	42	28	52	66

Figure 31. Percent of total riparian area that has been harvested (since 1946). Prior to 1946, less than 2 % of the watershed had been roaded and harvested (Watershed Analysis, 1995). Riparian areas were calculated by applying NWFP riparian reserve widths to all lands.

Summary of Management-Related Sediment Sources

Roads, landslides, and bank erosion are believed to be the dominant sources of sediment in managed systems and there is a strong interaction with storms. Canopy indirectly affects fluvial erosion through increased peak flows. Given riparian protection, landslides and roads become the dominant sediment sources likely to be influenced by management action (Norris et al 1999). In the Western Cascades, road fill failures were found to represent the most frequent cause of debris flow initiation (Swanson and Fredricksen 1982). In a study of landslides after a large storm event in the Cascade Range of Oregon, Wemple et al (1999) found that road-related erosion processes were a significant part of overall sediment production in the basin during large storm events. An Oregon Department of Forestry (ODF) study of landslides and storm impacts for the storms of 1996 concluded that while the number of road-related landslides were low, the size of these landslides were about 4 times larger on average than landslides not associated with roads. The ODF study as well as the landslide study in the Tuttle Creek and Engles Creek 7th field catchments show that landslides that enter stream channels are most common in steep, inner gorge areas adjacent to streams.

How these increased sediment inputs affect long-term in-stream sediment storage and transport is not clearly understood. Historically, it is likely that individual drainages were periodically highly impacted by sedimentation (due to episodic events such as landslides). Currently, most drainages are highly impacted.

Controllable Inputs

An overall average of 70% was used for estimating sediment reduction from management related activities. This is based on results from literature and other completed and approved TMDLs. Analysis for two completed sediment TMDLs in California show that sediment delivery for landslides due to management activity is 60% controllable (U.S. Environmental Protection Agency, Region 9, Redwood Creek TMDL 1998) and 80% controllable (U.S. Environmental Protection Agency, Region 9, Garcia River Sediment TMDL 1998). The recently approved Simpson Northwest Timberlands TMDL in Washington State based estimates of controllable sediment input on these two California TMDLs. Sediment delivery for road surface erosion has been estimated as 70% controllable (Burroughs 1989). Target sediment loading (Figure 32) is expressed as tons/mi^2/year. The target sediment loading is based on the Stillwater Sciences study data on the lower reach of the North Umpqua River (Stillwater Sciences 2000). The sediment budget for the Tuttle and Engles drainages in Little River was not used due to the small size of the analysis area.

Sediment Budget	Reference Condition (tons/mi.^{2}/yr)	Current Condition [a] (tons/mi.^{2}/yr)	Management Related (Current - Reference) (tons/mi.^{2}/yr)	Controllable Inputs [b] (tons/mi.^{2}/yr)	Target Condition [c] (tons/mi.^{2}/yr)
Input					
Landslides[d]	171[e]	798[e]	627		
Soil Creep	71	71	0		
Surface Erosion	14[f]	18[g]	4		
Total Inputs	256	887	631	442	445
Output	285[f]	1339[h]			
Storage Change	0[i]	(57)			

Figure 32. Target sediment loading for the Little River watershed.

[a]Current condition = management related + reference.
[b]Controllabe inputs = .70 x management related.
[c]Target condition = (management related + reference) - controllable load. An error range is estimated at ±50% for all figures (Stillwater Sciences, 2000).
[d]Landslide sediment inputs include rapid-shallow slope failures (including debris flows) that originate in colluvial hollows, as well as from slumps, and active toe zones of earth flows.
[e]This value is the average of sediment delivery rates based on landslide inventories in the Upper Steamboat basins and the Little River

AMA watershed analysis (using 1946 photos).
[f]From studies conducted by Swanson et al (1982) in the H.J. Andrews Experimental Forest, Oregon (Western Cascades lithography).
[g]Road surface erosion was estimated using SEDMODL and results indicate approximately 4.2 tons/mi²/yr.
[h](McBain and Trush 1998).
[i]Based on an assumption of long term equilibrium between inputs and outputs (i.e. no long-term net aggradation of degradation).

Restoration Actions and Milestones

It is difficult to quantify direct linkages among processes and functions outside the stream channel to in-channel conditions (FEMAT 1993). Due to natural sedimentation, high spatial and temporal variability in weather patterns and mass wasting, and difficulty in measuring sediment delivery/storage/transport in a stream over time it would be nearly impossible to definitively describe how much sediment a stream can accept and still meet water quality standards. It is also difficult to differentiate and measure the difference between natural and management-related sediment delivery at any specific point or time in the Little River watershed. We have attempted to characterize sediment sources, assess controllable inputs (i.e. management effects), and develop restoration actions and milestones to address these controllable inputs. When possible, conservative assumptions were used in the analysis to err on the side of the aquatic resource. This likely resulted in an overestimation of the amount of sediment production and delivery due to management activities. These include:

-The model (SEDMODL) used for calculating surface erosion from roads overestimates the number of sediment-delivering segments. While it assumes all roads within 200 feet of a stream deliver sediment, this is generally not the case.

-When analyzing rain-on-snow peak flows and potential bank erosion, a conservative assumption was used in estimating hydrologic recovery. It was assumed that forests <40 years of age had no hydrological recovery. In fact, hydrologic recovery of the canopy begins as soon as vegetation is re-established and continues until full recovery is achieved in 30-40 years.

Water quality indicators and restoration activity accomplishments will be used to track and monitor progress (see Chapter VI).

Milestones and priorities for restoration activity are based on addressing the highest existing and at-risk management-related contributors to detrimental sediment delivery and increased peak flows in areas where they will have the most positive effect for the beneficial use (fish). Restoration activities will substantially reduce federal management-related sediment delivery and hydrologic effects and move the sediment budget towards the natural condition on federal lands. Figure 33 provides a summary of actions and milestones.

Parameter	Management Actions (Desired Conditions)	Milestones
Use of clearcut and/or ground-based timber harvest Peak flows	Future harvesting avoids steep inner gorge, unstable, or streamside areas unless a detailed assessment is performed which shows there is no potential for increased sediment delivery to streams as a result. [1] Consider peak flows and hydrologic recovery when planning timber harvest to maintain appropriate canopy closure.	Ongoing
Road location in riparian, inner gorge, or unstable headwall areas	Future roads are not located in riparian, steep inner gorge or unstable headwall areas except where alternatives are unavailable.[2]	Ongoing
Road fill, cutslope, surface, and drainage	Roads have surface and drainage facilities or structures that are appropriate to their patterns and intensity of use. Unstable landings and road fills[3] that could potentially deliver sediment to a stream are pulled back and stabilized.	Review roads (with medium/high sediment delivery in landslide-earthflow areas) to verify the need for restoration and treat or decommission as needed. Treat or decommission other roads as indicated in project level planning efforts.
Road/stream crossings diversion potential, culvert size, and ditch length	Culverts are sized to pass 100-year flood and associated sediment and debris. Install cross drains to reduce ditch length at stream crossings. No crossings have diversion potential.	Review highest risk stream crossings to verify the need for restoration and treat as needed. Treat other stream crossings as indicated in project level planning efforts.
Large woody debris (LWD)	LWD in streams mimics natural conditions. Reintroduce fire into ecosystem.	Place LWD & reintroduce fire based on assessment of local conditions

Figure 33. Sediment-related restoration actions and milestones for Federal land in the Little River watershed.

[1] Characteristics of steep inner gorge, unstable, or streamside areas generally include the following (Redwood Creek TMDL, 1998):
-slopes > 50%
-located within 300 feet of a class 1, 2, or 3 stream
-erosive or incompetent soil type or underlying geology
-concave slope shape
-convergent groundwater present and/or evidence of past movement is present

[2] Steep inner gorge areas generally exceed 65% in slope and are located adjacent to class 1 or 2 streams. Characteristics of
steep unstable headwall areas generally include the following (Redwood Creek TMDL, 1998):
-slopes > 50%
-erosive or incompetent soil type or underlying geology
-concave slope shape
-convergent groundwater present and/or evidence of past movement is present

[3] According to the watershed analysis, unstable landings and road fills are generally those that are located on slopes >60%.

E. Habitat Modification

Introduction

The beneficial uses affected by habitat modification include resident fish & aquatic life and salmonid fish spawning & rearing. The relevant Oregon water quality standards are:

OAR 340-41-027 (Biological Criteria):

> *Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.*

And specifically for the Umpqua Basin [OAR 340-41-0285 (2) (i)]:

> *The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life, or affect the potability of drinking water, or the palatability of fish or shellfish shall not be allowed.*

A stream is listed as water quality limited if there is documentation that habitat conditions are a significant limitation to fish or other aquatic life.

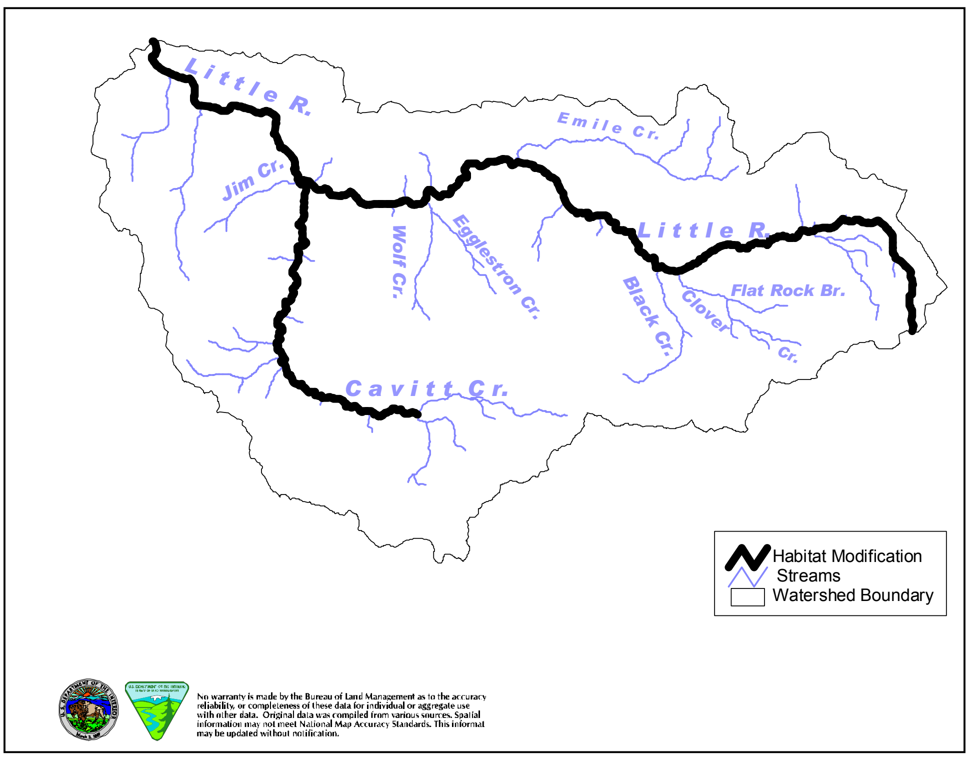

Figure 34. Little River stream segments currently listed for exceeding the habitat modification standard.

Habitat structure is an important, but often overlooked component of stream condition. Changes in riparian vegetation, floodplain interaction, substrate, and channel sinuosity influence the aquatic community of a stream. Protection and restoration of the physical and chemical characteristics of the

Little River and its tributaries is necessary to maintain and restore healthy aquatic ecosystems. Alterations to these water body attributes are considered an important factor in the decline of salmonid populations in Oregon. Water bodies with relatively good water quality have been shown to be biologically impoverished when habitat quality is poor.

The combination of large-scale in-stream wood removal in the 1960's and 1970's, extensive timber harvest along streams over the last 40 years, and the exclusion of fire from the ecosystem over the last 70 years, have negatively affected stream habitats essentially throughout the basin. Stream cleanout occurred throughout the fish bearing waters of the watershed, including most tributaries where substantial timber harvest and roading took place. Naturally occurring processes that may affect aquatic habitat include floods, fires, insect damage to vegetation, diseased vegetation, landslides, earth flows, mass wasting, and debris flows. These affects may be beneficial or adverse depending upon current watershed condition.

Historic information about fish habitat quantity and quality is sparse for the Little River system; most information was only recently collected (Little River Watershed Analysis 1995). Recent stream surveys and interpretation of historical and recent aerial photographs indicate that Little River watershed has been altered in the last 100 years. In the last 20 to 30 years the recognition of the importance of habitat to salmonids has altered many management activities that were detrimental to water quality and fish. ODF&W and USFS aquatic surveys are important historical information, and include data on large woody debris, channel complexity, stream substrate, and width/depth ratio.

Surveys conducted in 1993 by the Oregon Department of Fish and Wildlife (ODFW) in the lower half of the Little River watershed provide information regarding in-stream habitat. This data was analyzed to derive a relative indication of the quantity and quality of aquatic habitat by stream reach (Figure 35). The raw data under each habitat category can be compared to the categories at the top to determine whether or not the category is in excellent, good, fair or poor condition. The summary scores (at the right of the Figure) for each stream are a result of the raw data collected and are listed by stream name. The scores are an average of all stream reaches by name and reflect the quantity and quality of aquatic habitat at the time of survey. The relative overall condition of streams can be determined by comparing the scores with the habitat benchmark rating system, which is a range of scores for excellent, good, fair and poor. Flooding and other natural or anthropogenic disturbances subsequent to stream surveys may have altered the scores and more surveys are necessary to assess any changes in aquatic health. The raw data appear to vary considerably by category and stream reach, with the exception of stream shade and large woody debris. Shade values are mostly in the excellent range, whereas numbers and volume of in-stream large woody are in a poor category. An extensive discussion of habitat conditions within the main stem of Little River and its tributaries can be found within the Little River watershed analysis and its Appendix F.

Stream	Reach	% Pool Area	Residual Pool	Width/Depth ratio	% fines in riffles	% gravel in riffles	Large woody debris	Volume of wood	Average Score*
Excellent		≥45	≥0.6	≤10	≤1	≥80	≥30	≥40	82-100
Good		31-44	0.41-0.6	11-20	2-7	71-79	20-29	30-39	63-81
Fair		16-30	0.21-0.4	21-29	8-14	61-70	11-19	21-29	44-62
Poor		≤15	≤0.2	≥30	≥15	≤60	≤10	≤20	25-43
Bond Creek	1	10.7	0.4	25.5	44	31	5.1	8.3	
	2	13.6	0.3	7.8	47	41	12.7	31.2	50
Boulder Creek	1	32.2	0.2	21.8	42	26	7.8	10.3	
	2	30.9	0.3	16.3	54	22	15.2	36.8	
	3	47.1	0.3	7.1	46	31	7.2	25	
	4	1.6	0.5	10.7	71	28	8.6	20.7	
	5	0	0	--	26	16	8.6	28.6	46
Buckhorn Creek	1	33.6	0.5	27.8	40	54	1.6	0.8	
	2	20.8	.6	33.3	34	30	3.0	3.6	
	3	17.2	0.5	29.3	37.0	33.0	1.3	1.1	47
Buckshot	1	8.4	0.6	---	9.0	11.0	8.7	14.5	42
Cavitt Creek	1	67.6	0.9	49.5	6.0	13.0	0.3	0.1	
	2	48.4	1.4	45.2	8.0	17.0	0.4	0.2	
	3	46.0	0.9	37.9	8.0	12.0	0.2	0.2	
	4	56.8	1.0	29.5	0	15.0	2.7	3.0	
	5	53.2	0.9	75.8	6.0	92.0	5.3	4.5	
	6	75.4	1.0	64.0	7.0	68	7.6	5.3	
	7	35.8	0.8	67.2	1.0	41	1.6	1.2	
	8	38.5	0.7	15	9	27	8.2	13.7	49
Copperhead Creek	1	80	0.4	21.7	63	33	9.7	16.3	
	2	19.8	0.3	17.5	71	27	26.2	29.9	
	3	6.2	0.3	15.3	62	34	24.6	40.3	
	4	1.1	0.5	--	70	25	21.7	72.3	51
Egglestron Creek	1	5.8	0.5	--	--	--	15.6	45.5	
	2	3.3	0.8	10.7	18.0	49.0	1.7	5.5	48
Emile Creek	1	34.2	0.7	17.7	6.0	20	1.2	5.4	
	2	10.7	0.1	18.2	2.0	23	13.7	48.2	
	3	8.7	1	--	--	--	16.2	62.2	
	4	84.5	0.5	28.4	65	20	3	9.9	50
Evarts Creek	1	31.8	1.2	7	8	25	2	2.2	
	2	50.3	0.5	--	11	30	9.5	19.9	
	3	32.9	0.6	14.7	29	38	10.7	19.9	56
Fall Creek	1	16.3	0.7	24.5	33	36	1.5	2.3	
	2	11.6	0.6	24.2	32	35	5	12.2	
	3	15.4	0.9	26.1	44	33	12.8	39.4	44

Stream	Reach	% Pool Area	Residual Pool	Width/Depth ratio	% fines in riffles	% gravel in riffles	Large woody debris	Volume of wood	Average Score*
Greenman Creek	1	9.9	0.6	30	25	25	2.2	3.0	
	2	26	0.4	19.4	26.0	15	8.2	15.5	
	3	0	--	--	33	22	4	6.7	39
Jim Creek	1	20.5	.8	41.5	60	13	6.7	8.0	
	2	33	.8	27.5	12	32	9.6	24.7	
	3	37	0.4	23.3	35	23	16.1	23.6	
	4	38.4	0.4	22.4	31	31	17.6	39	
	5	46.8	0.4	18.5	49	31	26	99.7	
	6	48.9	0.3	14.8	43	33	24.2	39.1	58
Little River	1	14.7	1	--	23	32	--	--	
	2	17.1	1.1	--	28	31	--	--	
	3	33.1	1.1	--	36	22	--	--	
	4	24.9	0.6	--	42	34	--	--	44
McKay Creek	1	38.3	0.3	11	63	26	5.8	8.8	
	2	0	0	--	87	13	7.1	17.2	36
Mill Creek	1	9.5	0.3	10.5	34	42	34.8	28.7	
	2	1.1	0.4	20	20	40	31.9	89.2	59
Negro Creek	1	6.8	0.6	--	17	22	13.8	34.2	
	2	5.4	0.6	--	15	26	24.2	62.1	
	3	4.9	0.5	--	19	25	22	33.1	51
Negro trib #1	1	6.3	0.5	--	23	26	29.5	69	
	2	4.9	0.6	--	16	23	33.8	82.1	
	3	18.2	0.5	8.9	57	25	33	60.3	
	4	3.2	0.5	46.7	80	20	16.4	16.5	55
Springer Creek	1	30.7	0.4	23.9	44	21	14	44.9	
	2	22.9	0.2	10.5	60	28	30.3	184.6	56
Tuttle Creek	1	4	0.5	16.5	60	30	22.6	52.8	60
West Fork Wolf Creek	1	18.1	1.7	52.4	24	23	6.5	20.2	
	2	8.9	0.8	29.7	40	31	22.5	68.3	
	3	8.6	0.4	30.7	76	17	12.8	39	50
White Rock Creek	1	26.8	0.3	49	13	18	5.7	5.4	
	2	10	0.2	--	26	36	21.0	53.0	
	3	0	0	--	29	23	6.4	22.7	41
Wolf Creek	1	27.6	0.7	40.7	33	20	5.7	15.6	
	2	20.9	1.5	28.5	16	8	4.6	19.6	
	3	16.7	0.7	42	25	23	14.2	50.2	
	4	3.3	0.7	50	40	20	27.4	19.6	48
Range of values		0 - 84.5	0 - 1.7	7 - 67	0 - 80	8 - 92	0.2 - 34.8	0 - 184.6	36-60

Figure 35. Summary of ODFW 1993 surveys in (lower half of) the Little River watershed. Most streams were divided into reaches for survey purposes. Surveys run from the mouth to the headwaters. The average scores are based upon all of the habitat categories for the entire surveyed length.

Large Wood

Large wood creates pools, stores spawning gravels and fine sediments, and organic material, create habitat, and maintains channel morphology. Obstructions created by large wood help to settle out gravel. The deposition of gravel helps to decrease thermal loading by reducing the amount of water that is exposed to direct solar input, as a portion of the water will travel sub-gravel and not be exposed to solar radiation. In gravel-dominated streams, a large percentage of the flow may travel sub-surface with little opportunity for thermal loading.

The removal of large wood has had the greatest direct impact on stream channel morphology. Once large wood was removed, the alluvial material held behind it washed out, causing channels to down cut and eventually to widen, allowing for increased thermal loading.

Historical accounts recall that streams had “numerous pieces of wood both in and spanning the channel, often making travel and fishing difficult” (Little River Watershed Analysis 1995). In the larger tributaries and main stem, large debris jams often spanned the entire channel providing cover, feeding, and rearing areas for fish.

Large wood was removed for fish passage purposes as well as to protect stream-crossing structures that might be obstructed by the wood and debris (Little River Watershed Analysis 1995). Earlier harvest practices often removed most marketable timber from riparian areas. This included standing trees as well as in-stream wood and downed wood lying within floodplain areas. Wood was also salvaged in these areas during road building activities. Since the early 1900’s, fires have largely been suppressed, causing a reduction in the availability of natural downed wood. Current recruitment of new woody debris to the stream channel is slow due to the young age of the riparian vegetation. According to the watershed analysis, 72 to 88 % of the riparian areas within 360 ft. of fish bearing streams in the basin were in a late seral vegetation condition with large conifers and large hardwoods dominating the strands. Today, roughly 30% of riparian stands along fish-bearing streams are considered to have late seral characteristics.

The Oregon Coastal Salmon Restoration Initiative (CSRI) Conservation Plan (1997) developed an in-stream roughness objective:

> *The interim habitat objective for in stream roughness is 50% of the stream length (orders 2-5) will have 4 or more functional key pieces of wood per 100 meters of stream length. A functional key piece of woody debris has adequate length and diameter to be “stable” within a channel.*

Recent observations of the lower Little River recorded from 0 to 67 pieces of large woody debris/mile (Little River Watershed Analysis 1995). A survey along 14 miles of Little River above Wolf Creek found that the frequency of large wood debris averaged 19 pieces per mile. For comparison, Harkleroad (1993) reported finding 50 to 110 pieces of large woody debris per mile in roadless area stream reaches in other watersheds in the North Umpqua basin.

Channel Complexity (pools)

Research has demonstrated that channel complexity, especially slow water habitat, is a major limiting factor regarding fresh water habitat for coho salmon (Dolloff 1986). Pool habitat is an essential habitat element for rearing salmonids. Pools are most productive in combination with large wood, which also provides cover both in the summer and winter and velocity refuges during winter floods. Fish population surveys often find most coho salmon in slow water areas off channel, pools behind beaver dams and channel spanning pools (CSRI 1997). The Oregon CSRI Conservation Plan (1997) has set the following channel morphology objective for State coastal streams:

> *The interim habitat objective for channel morphology is 60% of the stream length (orders 2-5), 35% of the stream area is pool and for 60% of the stream length (orders 2-5), there will be no more than 5-8 channel widths between pools.*

Channel complexity is increased by frequently alternating fast and slow flowing reaches (pools and riffles). Channels that are complex tend to have higher proportions of slow water habitat created by large woody debris, meanders and beaver activity (Meehan 1991). Although no direct links between pools and sedimentation have been found, studies indicate excessive sedimentation may play a role in reducing pool depth and frequency (Lisle and Hilton 1992). Anecdotal observations during stream surveys on the North Umpqua Ranger District have documented reduction in pool volumes as a result of filling with fine sediment. Channel simplification has increased channel width, decreased channel depth and reduced pool size and frequency (Dose and Roper 1994).

The frequency of pools in the Little River and tributary streams has been likely impacted by channel simplification, lack of large woody debris, and sedimentation. Due to incomplete stream survey information, it is not possible to determine the total pool area in the Little River watershed. However, the frequency of pools measured by the number of channel widths separating the pools has been quantified and many stream segments do not satisfy the Oregon CSRI Conservation Plan (1997) channel morphology objective. As channel width increases, streams generally become shallower. It is expected that lower pool frequencies result from increasing these width/depth ratios.

Roads

Road construction throughout the Little River watershed often occurred in riparian areas, frequently adjacent to stream channels. Road construction near streams relies on hardening of stream banks, which can result in channelization of stream segments. Streams that are channelized lack most, if not all, complex habitat indicators (Reiter and Beschta 1995)). Excessive sediment from erosion and mass wasting can accumulate and increase channel width and reduce channel depth resulting in lower pool frequencies. Road construction and maintenance reduces large wood recruitment through continued salvaging along roads.

Aquatic Insects

Aquatic insects are sensitive to changes in aquatic habitat and are often used to assess the quality of habitat conditions. Aquatic insects serve as the primary food source for fish and play an important role in stream ecology. The Forest Service first completed Macroinvertibrate sampling in 1994. Survey results at eight sites indicate that the overall macroinvertebrate community has been moderately impacted (Figure 36). Most species found are considered tolerant to degraded habitat conditions. Many sites recorded the presence of aquatic worm, an indication of excessive sediment. The abundance of snail populations tolerant of poor water quality was attributed to filamentous algae. Upper Cavitt Creek was the only sample site with aquatic insects that ranked moderate to good with few habitat-sensitive species found. However, some tolerant species were found indicating declining habitat and water quality

Many past and some current land use activities such as timber harvest in riparian zones and the removal of in-stream wood have affected aquatic habitat in the Little River watershed. The result of these activities has reduced the recruitment of coarse woody debris. Sedimentation from chronic and episodic surface erosion and mass wasting from roads has likely reduced stream complexity.

Some of the best habitat in the Little River watershed is located along the upper main stem of the Little River where a canyon formed primarily of bedrock outcroppings constrains the river and allows deep plunge pools to form. This provides excellent habitat for steelhead rearing.

Tributaries to Little River and Cavitt Creek may also be important rearing and resting areas for fish as the main-stem of Little River and Cavitt Creek become too hot during the summer low flow period. These third, fourth, and fifth order tributaries may become thermal refuge areas. Additional stream surveys would be necessary to determine the amount and type of aquatic habitat in the Little River. Old growth conifers are virtually continuous along these sections of the river and tributaries and are a source of large woody debris and stream surface shade.

Vicinity	Sample Site	Overall Condition of Macroinvertebrate Community
Lower Little River	Near Mouth	**Fair to poor.** Low richness in mayfly: stonefly: caddis fly populations indicates impaired habitat/water quality. Numerous aquatic worms suggest an abundance of fine sediment.
Middle Little River	Above Cavitt Creek	**Fair to poor.** Similar to lower Little River site.
Middle Little River	Near Negro Creek	**Fair.** High richness in mayfly: stonefly: caddis fly populations indicates good habitat/water quality. Also, abundance of tolerant snails, black flies, and crane flies which are tolerant of excessive filamentous algae and/or disturbed enriched streams.
Cavitt	Near mouth	**Fair.** Moderate to low richness in mayfly: stonefly: caddis fly populations, but some highly sensitive species not tolerant of certain degraded habitat conditions also found. Moderate black fly numbers indicate somewhat depressed habitat or water quality.
Cavitt	Upper (above Cultus Creek)	**Moderate to good.** High richness in mayfly: stonefly: caddis fly populations with several sensitive species corresponds to high habitat complexity and integrity. A few tolerant species also found indicating perhaps declining habitat or water quality
Emile	0.35 u/s of mouth	**Fair.** Low richness in mayfly: stonefly: caddis fly populations with only a few sensitive species found. Aquatic worms and dragonflies tolerant of warm water, fine sediment and low dissolved oxygen present.
Black Clover	0.25 mile u/s of mouth of Clover Creek	**Fair.** Low to moderate richness in mayfly: stonefly: caddis fly populations however several sensitive species found that prefer cool water and won't tolerate fine sediments and high winter scour or gravel resorting. Moderate numbers of tolerant caddis flies also found pointing to a general decline in habitat or water quality.
Black Clover	0.25 mile u/s of mouth of Black Creek	**Fair to poor.** Low richness in mayfly: stonefly; caddis fly populations with very few sensitive species found. Moderate numbers of tolerant dragonflies, snails, caddis flies, and aquatic worms. Usually indicative of high summer water temperatures, nutrient enrichment, sediment input and/or low flows.

Figure 36. Summary of US Forest Service aquatic insect samples collected in 1994 (Little River Watershed Analysis 1995).

No formal load allocation is proposed for the habitat modification parameter. Habitat modification is not viewed as a water quality pollutant under the Clean Water Act, however, it may be viewed as an end result of other water quality parameters that have been negatively affected.

Management Actions

Restoration measures include a combination of protective and restorative measures to achieve water quality and fisheries habitat goals. Protective measures can be defined as the cessation of those human activities causing degradation, or preventing recovery of aquatic functions and processes. Restorative measures recover ecological processes and functions.

Protective measures include allowing wood to remain in channels and allowing riparian vegetation to grow to improve large wood recruitment and bank stabilization.

Restorative measures include the placement of in-stream large wood and the re-introduction of fire into the ecosystem to help restore previously existing aquatic habitat. If the problem is too little LWD and too much sediment, priority for restoration measures may be to reduce sediment inputs first and place in-stream structures second (FEMAT 1993). The watershed analysis recommends that in-stream work be addressed after substantial progress is made on restoring upslope processes. The intention is that management action should focus on the causes of the problems rather than the symptoms. Therefore, targets for in-stream wood will not be set. Instead, prescribed fire and placement of wood in streams will be done as opportunities occur and will be based on an assessment of local conditions (where it is likely to historically accumulate, where downed wood is readily available, where habitat is needed, and in stream reaches that are depositional).

Restorative measures to address the temperature and sediment listings will also improve aquatic habitat. Figure 37 provides a summary of habitat elements, affected processes, and management actions. The figure shows that a particular management action can affect numerous processes and that it is important that actions occur in both upland and riparian areas.

Habitat Elements	Affected Process	Management Actions	
		Upland	Riparian
Water Temperature	Riparian canopy closure		Maintain effective stream buffers, apply silviculture treatments to enhance growth/diversity in riparian plantations
	Sedimentation	Prevent landslides in harvest areas	Decommission/improve roads
	Increased peak flows/channel scour	Maintain canopy closures, decommission/improve roads	Maintain effective stream buffers
	In-stream wood		Add wood to streams, reintroduce fire
Sediment	Landslides	Decommission/improve roads, locate and avoid unstable land	Maintain effective stream buffers
	Road surface erosion	Decommission/improve roads	Decommission/improve roads
	Stream crossing failures	Decommission/improve roads	Decommission/improve roads
	Stream bank erosion	Maintain canopy closures	Add large wood, reintroduce fire
Flows	Bank erosion/channel scour	Maintain canopy closures	Add wood to streams
	Stream extension/road ditchlines	Decommission/improve roads	Decommission/improve roads
Stream Structure	Stream cleanout		Add wood to streams
	Fire	Reintroduce fire	Reintroduce fire
	Bank erosion/ increased peakflows	Maintain canopy closures, decommission/improve roads	Apply silviculture treatments to enhance growth/diversity in riparian plantations

	Riparian harvest		Apply silviculture treatments to enhance growth/diversity in plantations

Figure 37. Habitat elements, affected processes, and potential active restoration options for the recovery of habitat for salmonid fish.

II. Goals, Objectives, and Management Actions

Endangered Species Act, Clean Water Act, NWFP, and Land Management Plans
The Endangered Species Act (ESA) and the Clean Water Act (CWA) are two federal laws which guide public land management. These laws are meant to provide for the recovery and preservation of endangered and threatened species and the quality of the nation's waters. The BLM and USFS are required to assist in implementing these two laws. They provide the overall frame of reference for federal land management policies and plans pertaining to water quality and endangered species.

The Northwest Forest Plan (NWFP) and land management plans are mechanisms for the USFS and BLM to implement the ESA and CWA. They provide the overall planning framework for the development and implementation of this WQRP. The NWFP's Aquatic Conservation Strategy (ACS) was developed to restore and maintain the ecological health of watersheds and aquatic ecosystems on public lands. The NWFP requires federal decision makers to ensure that proposed management activities are consistent with ACS objectives. ACS objectives are listed on page B-11 of the NWFP Record of Decision (ROD). ACS objectives 3-7 contain guidance related to maintaining and restoring water quality. In general, the objectives are long range (10 to 100 years) and strive to maintain and restore ecosystem health at the watershed scale.

The Resource Management Plan (RMP) for the BLM Roseburg District, and the Land and Resource Management Plan (Forest Plan) for the Umpqua National Forest provide for water quality and riparian management and are written to ensure attainment of ACS objectives. These plans contain Best Management Practices (BMP's) which were created to prevent or reduce water pollution to meet the goals of the Clean Water Act.

WQRP Goals
Guided by the relevant laws, policies, and plans as described above there are two goals for this WQRP:

1. Protect existing areas where water quality meets standards and avoid future impairments.
2. Restore existing areas that do not currently meet water quality standards.

WQRP Objectives

The following WQRP objectives result from the laws, policies, and plans described above as well as the analysis of the individual water quality limited parameters as described in Chapter I of this document. On public lands, watershed restoration is critical in aiding recovery of aquatic habitat and water quality. Protective objectives seek to prevent further water quality impairment and restorative objectives seek to reduce existing impairments by restoring habitat to the conditions under which aquatic ecosystems evolved.

Protective objectives:

- Minimize management actions in upslope areas that negatively impact water quality
- Minimize management actions in riparian areas and streams that negatively impact water quality

Restorative objectives:

- Reduce existing and potential sediment delivery to streams
- Reduce road effects on the natural flow regime
- Increase riparian shade to reduce water temperature and pH
- Restore in-stream habitat complexity

Management Actions and Milestone

Management actions are specific actions that lead to the desired long-term conditions. Where appropriate, milestones are included which describe interim targets. Milestones are meant to address the highest existing and at-risk management-related contributors to water quality problems. The following actions and milestones resulted from the analysis of the individual water quality limited parameters as described in Chapter I of this document. Timelines for accomplishment of milestones are dependent on costs and budget and are therefore discussed in Chapter III.

	Objective	Management Actions (Desired Conditions)	Milestones
PROTECTIVE	Minimize management actions in upslope areas that negatively impact water quality	Future harvesting avoids steep inner gorge, unstable, or streamside areas unless a detailed assessment is performed which shows there is no potential for increased sediment delivery to streams as a result. Consider peak flows and hydrologic recovery when planning timber harvest to maintain appropriate canopy closure.	Ongoing
	Minimize actions in riparian areas and streams that negatively impact water quality	Maintain effective riparian buffers when harvesting timber Future roads are not located in riparian, steep inner gorges, or unstable headwall areas except where alternatives are unavailable. Minimize removal of large wood from channels	Ongoing

RESTORATIVE	Reduce existing and potential sediment delivery to streams Reduce road effects on the natural flow regime	Roads have surface and drainage facilities or structures that are appropriate to their patterns and intensity of use. Unstable landings and road fills that could potentially deliver sediment to a stream are pulled back and stabilized. Culverts are sized to pass 100-year flood and associated sediment and debris. Install cross drains to reduce ditch length at stream crossings No crossings have diversion potential.	Review roads (with medium/high sediment delivery and longest ditch lengths) to verify the need for restoration and treat or decommission as needed. Treat or decommission other roads as indicated in project level planning efforts. Review highest risk stream crossings to verify the need for restoration and treat as needed. Treat other stream crossings as indicated in project level planning efforts.
	Increase riparian shade to reduce water temperature and pH	Increase growth rate in riparian areas through silvicultural practices.	Implement silvicultural prescriptions to meet ACS as determined by project planning prescriptions.
	Restore in-stream habitat complexity	LWD in streams mimics natural conditions. Reintroduce fire into ecosystem.	Place LWD and reintroduce fire based on assessment of local conditions.

Figure 38. WQRP objectives, management actions, and milestones.

Priority Areas for Restoration

In the NWFP, key watersheds provide the refuge areas for maintenance and protection of aquatic populations. With time, species are predicted to re-populate other areas (non-key watersheds) as they begin to recover. Little River was not identified as a key watershed in the NWFP, so it is not currently a top priority for restoration at the Umpqua National Forest and Roseburg BLM District level. However, restorative projects within Little River will be pursued to the extent possible via revenue-generating project funding and grants.

With a refuge strategy in mind, a rating system was developed to select likely refuge sub-watersheds where restoration of aquatic habitat would be most effective. As shown in Figure 39, the best opportunities for focused restoration would be Emile, Wolf Creek, and Cultus Creek. These sub-watersheds have the best water quality, large amounts of contiguous federal lands, and historic diverse fish distribution.

Sub-watersheds	Summer Water Temp	Federal Owner-ship	Diverse Fish Stocks Present	Refuge Potential	Rational/Comments
Watson Mountain	**-**	-	+	Low	High temps, low federal ownership. Jim Creek 7th field has potential
Red Butte	**-**	-	+	Low	High Temperatures
Middle Little River	**-**	-	+	Low	High Temperatures White & Negro 7th fields have potential
Little River Canyon	**+**	+	+/-	Med	Low fish diversity
Upper Little River	**+**	+	_	Low	Low fish diversity. Listed as reference basin in W.A.
Emile	**+***	+	+	High	Listed as reference basin in W.A.
Wolf	**+***	+	+	High	Blocked up BLM ownership
Black	**+**	+	-	Mod	Low fish diversity
Clover	**+/-**	+	+	Mod	Low fish diversity
Lower Cavitt	**-**	-	+	Low	High temperatures, low Federal ownership. Evarts 7th field has some potential
Middle Cavitt	**-**	-	+	Mod	High Fish Diversity overrides temp & 0wnership. Tuttle Cr. 7th field is W.A. reference basin
Cultus	**+**	+	+	High	Listed as reference basin in W.A.
Upper Cavitt	**+**	+	-	Low	Low fish diversity

Figure 39. Prioritization matrix of potential refuge basins in Little River. + indicates good conditions for a potential refuge and - indicates less opportunity to function as a refuge. *While Emile and Wolf currently exceed the rearing temperature standard, the have excellent potential to reach the standard with the proposed restoration.

In addition, collaborative restoration efforts between the Roseburg BLM, Umpqua National Forest, Seneca-Jones Timber Company, and the Umpqua Basin Watershed Council are already underway in Cavitt Creek. Middle Cavitt Creek will likely be the focus since it contains a mix of public and private lands.

The Little River Watershed Analysis identified Upper Little River and Clover Creek as sub-watersheds that have substantial existing healthy channel and riparian conditions that are functioning within reference conditions. It is important to continue to protect and maintain riparian conditions in these areas; therefore, these sub-watersheds will also be considered priorities for restoration.

Watershed restoration should address causes of degradation rather than symptoms (FEMAT 1993). While in-stream projects can be an important component of an overall program of restoring fish habitats, these measures are inherently short term (FEMAT 1993). The watershed analysis recommends that in-stream work be addressed after substantial progress is made on restoring upslope processes. In-stream restoration will be accomplished as budgets afford and opportunities arise, but road restoration will be the primary focus for active restoration. Roads affect numerous upslope and in-stream processes such as sedimentation, increased peak flows/channel scour, landslides, surface erosion, stream/road interactions, stream extension, and bank erosion. Road restoration can improve multiple fish habitat elements including water temperature, sediment, stream flows, and stream structure.

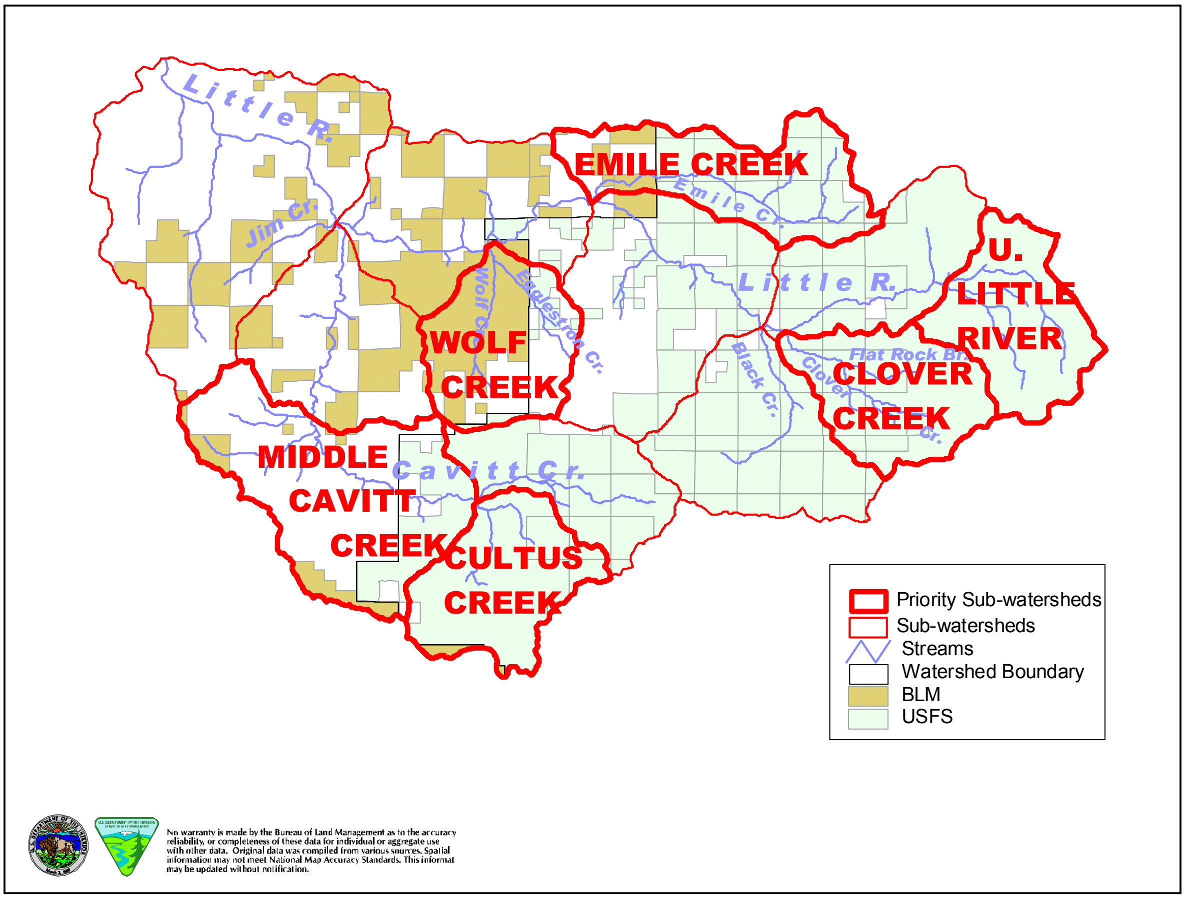

Figure 40. Restoration Priorities in Little River.

III. Time Line for Implementation, Cost, and Funding

Timeline

The problems leading to water quality limitations and 303(d) listing have accumulated over many decades. Natural recovery and restorative management actions to address these problems will occur over an extended period of time. Implementation will be continued until the restoration goals, objectives, and management actions as described in this WQRP are achieved. While active restoration may provide immediate, localized improvement, recovery at the watershed scale is long term in nature. The Aquatic Conservation Strategy contained in the NWFP describes restoration timeframes. ACS seeks to "prevent further degradation and restore habitat over broad landscapes as opposed to individual projects or small watersheds. Because it is based on natural disturbance processes, it may take decades, possibly more than a century to achieve objectives." It must be noted that 37% of the watershed is under private jurisdiction. While partnerships with private, local, and state organizations will be pursued, the BLM and USFS can only control the implementation of this WQRP on public lands.

Though most of the habitat for anadromous species is located in the main stems of Little River and Cavitt Creeks, much of this habitat is unsuitable for use during the summer months due to high stream temperatures. Lowering stream temperatures in the main stems in both the Little River and Cavitt Creek systems is of critical importance to the long-term survival of salmonids in the basin. Shade modeling indicates natural recovery of riparian growth from past stream-side harvesting is expected to take between 0 and 75 years (see Figure 16). . On public lands, progress over the long term is expected through natural recovery as these riparian areas are now protected from clear-cut harvest. Silvicultural treatments will be applied as appropriate for meeting ACS objectives and will be based on project level planning prescriptions. These treatments may reduce the timeline for achieving target shade levels.

Hydrologic conditions in forest stands will improve on public lands as the NWFP continues to be implemented. Here again, natural recovery will occur and result in a restorative trend in peak flows in select locations. Elsewhere this trend is unlikely to occur.

The recovery of in-stream wood levels is also on the scale of many decades. Naturally occurring fire, an essential mechanism for recruiting wood into streams, continues to be suppressed. Prescribed fire will be applied when possible but is currently too cost prohibitive to be widely used. Recovery will also occur with the re-growth of harvested riparian areas and eventual recruitment of mature and old growth trees into streams.

The existing road system with its unstable cuts and fills, extensive ditch lines, and potential water diversion problems will continue to contribute to sediment delivery and peak flow problems. Here, an active restorative approach is required. The timeline for road-related restoration milestones is 50 years. This is based on the estimated restoration costs as noted above and a planned funding level (from all sources) of approximately $100,000/year. If a higher level of revenue generating activities resumes (than today's level) and/or higher amounts of grant money are secured, this timeline may be accelerated.

Cost and Funding

Active restoration can be quite costly. Costs will vary with the level of restoration but the following are average costs of typical restoration activities (implementation only, does not include planning costs):

Full road decommission:	$26,000/mile
Road improvements:	$40,000/mile
Major culvert removal/replacement:	$55,000/culvert

Following is an estimate of potential restoration costs for accomplishing WQRP milestones:

30 miles of road improvements:	$1,200,000.
68 culvert replacements:	$3,740,000.
10 miles of road decommissioning:	$260,000
Total:	**$5,200,000**

There are several sources of funding for restoration activities. This includes revenue generating activities (such as timber sales), budget line items for restoration, and grants.

Revenue Generating Activities
Traditionally, the main revenue generating activity has been timber sales. Funds from timber sales are used to improve and restore roads associated with the timber sale.

Budget Line Items for Restoration
The Roseburg District BLM, Swiftwater Field Office annual restoration budget (Jobs In The Woods) has averaged $500,000 from FY1995 – FY 2000. The North Umpqua Ranger District annual restoration budget has averaged $250,000. Generally, line item funding is directed to key watersheds. Little River is not a key watershed.

Grants
This includes grant money from federal and state programs such as the Oregon DEQ 319 Non Point Source (NPS) Water Quality program and the Oregon Watershed Enhancement Board (OWEB). Generally, this grant money is intended for organizations involved in improving water quality. The BLM and USFS have been working with the local Umpqua Basin Watershed Council to forge partnerships to complete restoration projects on a cooperative basis.

Work will be accomplished to improve water quality as quickly as possible by addressing the highest existing and at-risk management-related contributors to water quality problems. Every attempt will be made to secure funding for restoration activity accomplishment but it must be recognized that the federal agencies are subject to political and economic realities. Currently, timber harvest is minimal due to lawsuits and the requirements of the clearances needed to proceed. If this situation continues, a major source of funding is lost. Historically, budget line items for restoration are a fraction of the total requirement. Grants may prove to be an increasingly important mechanism for funding restoration but are subject to funding availability and approval of external parties. Therefore, it is important to note that restoration actions are subject to the availability of funding.

Another important factor for implementation time lines and funding is that managers must consider Little River along with all other watersheds under their jurisdiction when determining budget allocations. In the areas of the Umpqua Basin administered by the Roseburg BLM or Umpqua NF, there are 28 5th field watersheds representing 1,369,401 acres that will require WQRP's (Figure 41).

Watershed	Total Acres	Federal Acres	Roseburg BLM	Umpqua NF	Other Federal*
Little River	**131,847**	**82,462**	**19,262**	**63,200**	
Boulder Creek/N.Umpqua River	19,491	19,491		19,491	
Calapooya Creek	157,189	11,956	11,956		
Canton Creek	40,559	30,866	17,689	12,924	253
Clearwater Creek	50,105	50,105	0	50,105	
Elk Creek/S. Umpqua River	54,348	33,409	192	33,125	192
Elk Creek/Umpqua River	187,229	45,095	42,709	0	737
Fish Creek	65,021	65,021	0	65,021	
Jackson Creek	102,329	96,147	0	96,147	
Layng Creek	126,868	96,483	57	86,731	9,694
Lemolo Lake	76,922	76,404	0	76,404	
Lower Cow Creek	102,444	39,943	39,543	0	400
Lower N. Umpqua River	106,190	12,401	12,401	0	
Lower S. Umpqua River	110,417	4,154	4,154	0	
Middle Fork Coquille River	197,060	59,226	19,750	0	39,476
Middle N. Umpqua River	123,911	111,029	11,889	99,140	

Middle S. Umpqua River/Dumont Creek	98,954	86,281	10,566	75,715	
Middle S. Umpqua River/Rice Creek	59,394	7,677	7,677	0	
Myrtle Creek	76,262	31,108	31,005	103	
Ollala Creek/Lookingglass Creek	103,105	27,389	27,389	0	
Rock Creek/N. Umpqua River	62,696	28,434	27,863	142	429
S. Umpqua River	141,450	60,646	57,595	2,487	564
Steamboat Creek	104,673	102,986	0	102,986	
Upper Cow Creek	47,435	33,955	489	24,043	9,423
Upper N. Umpqua River	54,587	54,586	0	54,586	
Upper Smith River	95,551	56,582	25,712	0	30,870
Upper S. Umpqua River	87,046	86,914	0	86,914	
Upper Umpqua River	169,470	58,714	52,337	0	6,377
Totals	2,752,553	1,469,463	**420,135**	**949,266**	100,063

Figure 41. Watersheds in the Umpqua Basin with land administered by the Roseburg BLM or Umpqua NF that require WQRP's. *Other federal includes Coos Bay, Eugene, and Medford BLM Districts.

The Umpqua National Forest has created a Restoration Business Plan. Little River is currently listed as 4th in priority for restoration. The BLM Roseburg District is developing an overall District restoration plan. Results of the Umpqua Basin Watershed Council's prioritization process resulted in Little River tied for 5th (with 3 other watersheds) on the priority list for the North Umpqua sub-basin. Funding and priorities may change as restoration plans adapt to changing physical, economic, and political factors.

IV. Identification of Responsible Parties

This Water Quality Restoration Plan (WQRP) covers federal lands and was jointly created by the Roseburg District BLM and the Umpqua National Forest with the assistance of Oregon Department of Environmental Quality (DEQ). Both federal agencies will be responsible for implementing the management actions contained in this plan. The federal officials responsible for the creation, implementation, and maintenance of this WQRP are the District Ranger, North Umpqua Ranger District, Umpqua National Forest; and the Field Manager, Swiftwater Field Office, Roseburg BLM.

This WQRP will be submitted to and used by the DEQ in creating an overall Water Quality Management Plan (WQMP) for Little River. The WQMP will cover all land within the Little River watershed regardless of jurisdiction or ownership.

Other organizations or groups that are (or will be) involved in partnerships for implementing, monitoring, and maintaining this plan include the Umpqua Basin Watershed Council, the Little River Committee, U.S. Geological Survey (USGS), Douglas County Natural Resources, Oregon Department of Fish and Wildlife (ODFW), Oregon DEQ, and the citizens of Little River.

Additional discussion of roles and responsibilities regarding plan implementation, monitoring, and maintenance of this effort over time can be found in chapters III, VI, and VIII.

V. Reasonable Assurance of Implementation

Responsible Federal Officials

The North Umpqua District Ranger (USFS) and the Swiftwater Field Manager (BLM) are responsible for ensuring this WQRP is implemented, reviewed, and amended as needed. These officials are responsible for all WQRPs for lands under their jurisdiction. They will ensure coordination and consistency in plan development, implementation, monitoring, review, and revision. They will ensure priorities are monitored and revised as needed. They will review and consider funding needs for this and other WQRP's in annual budget planning.

The two agencies are committed to not only working cooperatively with each other but with all interested parties in the watershed. This includes watershed councils, other government agencies, and private entities. The problems affecting water quality are widespread. We must coordinate activities and seek innovative partnerships to accomplish needed restoration.

The Umpqua National Forest and the Roseburg BLM have jointly developed this WQRP and fully intend to implement this plan within current and future funding constraints. Since 1995, the two agencies have been closely cooperating activities for the Little River Adaptive Management Area (AMA) which covers all federal lands within the Little River watershed. This includes creating a joint AMA Plan and Watershed Analysis along with cooperative project planning and implementation. If implementation problems such as disagreements regarding BMP's or priorities should arise, the two agencies will make a good faith attempt to resolve the disagreements. If this does not succeed, the WQRP will be amended to fully reflect the issue.

VI. Monitoring and Evaluation

Northwest Forest Plan and Federal Land Management Plans

The Northwest Forest Plan (NWFP), The Resource Management Plan (RMP) for the BLM Roseburg District, and the Land and Resource Management Plan (Forest Plan) for the Umpqua National Forest are ongoing federal land management plans. The NWFP became effective in 1994. Federal law requires the RMP and the Forest Plan. The RMP was implemented in 1995 and covers a period of approximately 10 years or until the next RMP is completed. The Forest Plan became effective in 1990 and also covers a period of approximately 10 years or until the next Forest Plan becomes effective. These plans contain extensive requirements for implementation, effectiveness, and validation monitoring of best management practices (BMP's) for water resources. Annual Program Summary and Monitoring Reports provide feedback and track how management actions are being implemented.

Regulations under the National Forest Management Act (36 CFR 219.12, k) require that Forest Plan implementation be evaluated periodically on a sample basis to determine how well objectives have been met, and how closely management Standards and Guidelines have been followed. These monitoring requirements have been incorporated into the Forest Plan. Monitoring serves as the basic tool to evaluate management direction and to determine if there is a need to amend or revise the Plan or to change the way management activities are conducted.

The RMP will be implemented over a period of years. Monitoring will be conducted as identified in the approved plan. Monitoring and evaluations will be utilized to ensure that decisions and priorities conveyed by the plan are being implemented, that progress toward identified resource objectives is occurring, and that mitigating measures and other management direction are effective.

WQRP Monitoring and Evaluation

Monitoring and evaluation will be accomplished within the framework of existing land management plans as described above. There are two major categories of monitoring that will occur for this WQRP. This includes restoration activity accomplishments (did we complete the management action targets) and water quality indicators (did we achieve the desired water quality).

Restoration Activity Accomplishments

As restoration activities are completed they will be tracked by each agency in local databases. This data will be annually provided to the Interagency Restoration DAtabase (IRDA). This database was developed by the Regional Ecosystem Office (REO) to track all restoration accomplishments by federal agencies in the areas covered by the NWFP. It is an ArcView based application and is available via the Internet at the REO website (www.reo.gov). It also contains data from the state of Oregon. The IRDA is intended to provide for consistent and universal reporting and accountability among federal agencies and to provide a common approach to meeting federal agency commitment made in monitoring and reporting restoration efforts in the Oregon Coastal Salmon Restoration Initiative. Activities that are tracked include in-stream structure and passage, riparian treatments, upland treatments, road decommissioning and improvements, and wetland treatments.

In addition, implementation and effectiveness monitoring will be accomplished for restoration projects according to project level specifications and requirements.

Water Quality Indicators

Water quality indicators are critical for assessing the success of this WQRP. This data will be used to monitor the success of plan implementation and effectiveness. Ongoing monitoring will detect improvements in water quality conditions as well as progress toward reaching the water quality standard. The core indicators of water quality and stream health that will be monitored are:

- Water Temperature
- Stream Flow
- Macroinvertibrates
- Stream Surveys
- Stream shade
- pH
- Pebble counts, Core Sampling

Water Quality Parameter	Indicator	Frequency
Water Temperature	Temperature <= 64° (7) day moving average of the daily maximum for rearing (6/1-9/30) Site Potential Stream Shade Stream Flow	Annually 5 years Annually
pH	pH within a range of 6.5 – 8.5	Annually
Sediment	Macroinvertibrates <=60% impaired Pebble Counts Core Sampling	Annually Annually TBD
Habitat Modification	Stream Surveys show PFC* or good rating	10 years or TBD

Figure 42. Water quality indicators for the Little River watershed. *Proper Functioning Condition

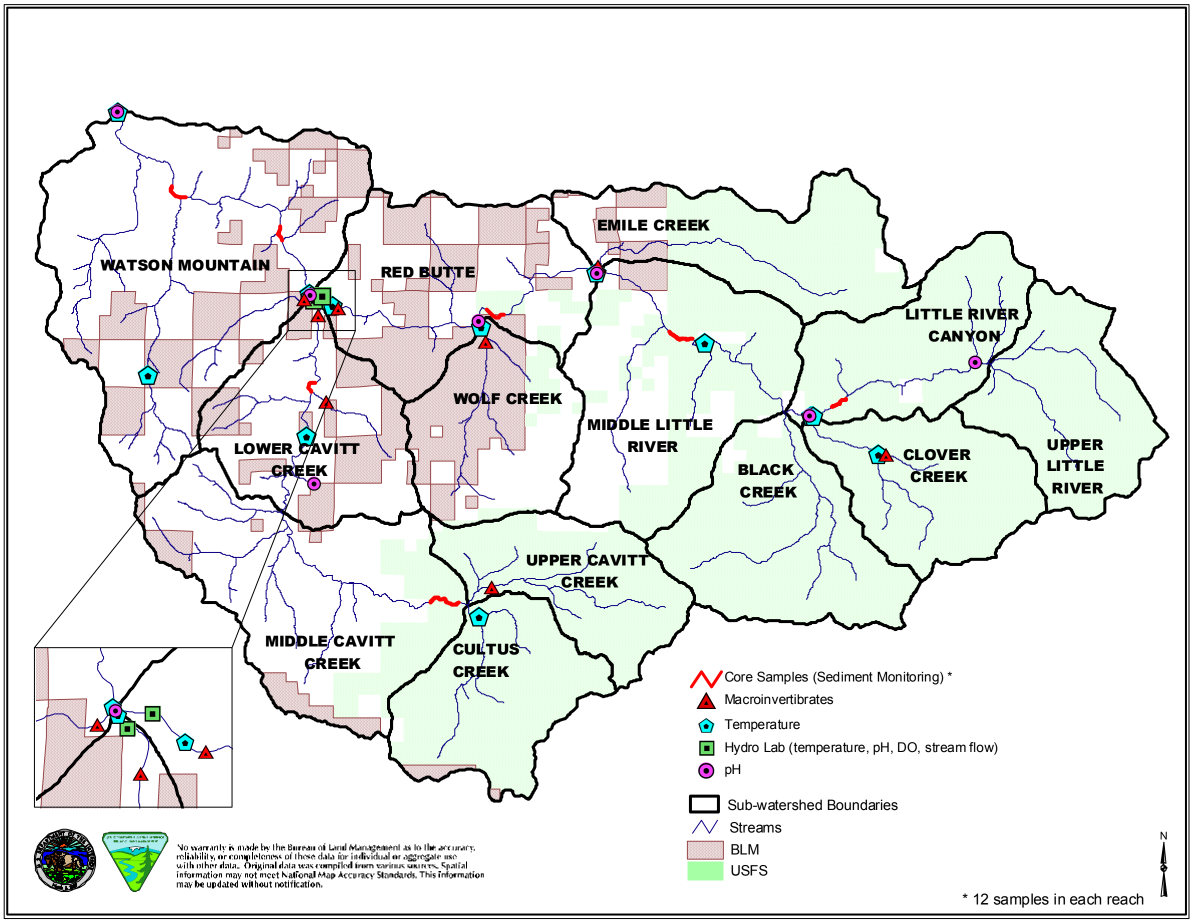

Figure 43. Location of USFS and BLM water quality monitoring sites.

Water Temperature

The BLM and USFS have collected stream temperature data since 1994 and will continue to monitor stream temperatures in order to detect any changes in temperature from long-term data sets. Sampling methods and quality control will follow ODEQ protocol. Several long term monitoring sites as well as project-specific, short-term sites will be used. Core long-term sites that will be monitored annually include:

BLM: Mouth of Cavitt Creek, Egglestron Creek, Emile Creek, Fall Creek, Lower Jim Creek, Little River (above Wolf Creek), Wolf Creek above Egglestron

USFS: Cultus Creek(mouth), Clover Creek (mouth), Little River (above Clover Creek), Flat Rock

Branch, Little River (below White Creek)

The USGS collects and publishes stream flow information. Stream flow was continuously monitored on Little River above Peel, OR until 1989 when the gauging station was discontinued. As a result of recommendations in the watershed analysis, this station was re-established in 1999 through a joint funding initiative by the BLM and USFS. Numerous other sites have been monitored by the USGS in the past and historical data is available on the Internet (www.usgs.gov). Stream low flows are also measured during annual temperature monitoring.

Stream shade will be monitored in selected reaches where there are long-term temperature monitoring sites to help review progress towards meeting the temperature standard and shade targets.

pH

Data on pH was collected in 1994 in support of the Little River watershed analysis and again in 1995 to verify the 1994 results. The USFS and BLM jointly fund two hydrolabs in Little River and Cavitt Creek that collect pH data (along with a number of other parameters).

It was determined by Oregon DEQ that additional information was needed to develop a TMDL for pH. Equipment was deployed the week of August 28, 2000 to collect data for a continuous 24-hour period on temperature, Dissolved Oxygen, pH, conductivity, and dissolved solids. In addition, readings for alkalinity, nutrients, and BODs were taken. Data was collected at the following locations:

BLM: Little River (mouth), Little River (above Wolf Creek)
BLM & USFS: Little River (river mile 8)*, Cavitt Creek (just upstream of Little River confluence)*
BLM & DEQ: Little River (above Emile Creek)
DEQ: Little River (below Clover Creek), Little River (below Pinnacle Creek), Cavitt Creek (0.7 river miles upstream of Buckshot Creek)

*Each Hydrolab site is monitored annually for at least 24 hours during summer low flows.

Sediment*

Macroinvertibrates (aquatic insects) will be the primary tool used to monitor how impacted aquatic life is responding to changes in stream habitat. Sampling was completed by the USFS in 1994, 1997 and 1999. The BLM developed a long term monitoring plan in 2000 and sampling will be conducted annually according to DEQ protocols. Long term monitoring sites include:

BLM: Wolf Creek, Jim Creek, Evarts Creek, Flat Rock Branch of Clover Creek
USFS: Lower Cavitt Creek, Upper Cavitt Creek, Emile Creek, Middle Little River

Limited data on in-stream sediment has been collected. Several techniques have been used to monitor sediment in streams. The BLM performs a pebble count when taking macroinvertibrate samples. Results will be reviewed to assess changes in particle size. The USFS performed core sampling (using a mechanical device to take a core from stream) in 1995 at a cost of $11,800. This data is currently being analyzed. Other available techniques include grid toss, embeddedness, substrate scoring, and V* Pool Index. The cost and labor involved with the various techniques range from minimal (pebble counts, grid toss, embeddedness, substrate scoring) to significant (V* and core samples). Critical considerations for the timing and placement of sampling include examining the effects of sediment on fish spawning, rearing, and food production. In FY2001, the BLM and USFS will review current methodology, timing, sampling frequency, numeric targets, and sites to determine if any changes should be made.

Habitat Modification

Stream survey data (pools, LWD, substrate, width/depth ratio, etc…) has been collected by the BLM and USFS. The BLM contracted with ODFW to complete stream surveys on 79 miles of streams in the lower half of the Little River watershed in 1993. The USFS uses an agency-specific protocol and completed stream surveys on 60 miles of stream in 1994. Due to the difference in protocols, the two data sets are not directly compatible. These surveys are quite costly (up to $1,000/mile) and time consuming. Some elements of the surveys may not be repeatable due to subjective ocular measurements. Due to these issues, stream habitat surveys are valuable as a snapshot in time but may not serve as a good monitoring tool. Currently, the Umpqua National Forest Land and Resource Management Plan provides for these surveys to be completed at 10-year intervals. The BLM does not currently have plans to repeat them. The two agencies will continue to evaluate the applicability and value of this methodology as a monitoring tool.

Monitoring Data and Adaptive Management
Currently, USFS and BLM hydrologists meet quarterly to review water quality data collection. These meetings will continue and will be framed in the context of reviewing the requirements of this WQRP. Data will be normalized and summarized annually and posted to the Little River AMA website (www.teleport.com/~lrama).

This WQRP is intended to be adaptive in nature. Sampling methodology, timing, frequency, and location will be refined as appropriate based on lessons learned, new information and techniques, and data analysis. A formal review involving USFS, BLM, and DEQ will take place every five years to review the collected data and activity accomplishment. This ensures a formal mechanism for reviewing accomplishments, monitoring results, and new information.

**It is also important to note that a rotary-screw smolt trap located in Little River, approximately 5-6 road miles from its confluence with the North Umpqua River, was operated from 1995 - 2000. It was used to trap, identify, and count fish migrating from Little River. Data from this smolt trap were used in the Watershed Analysis to describe the early emergence of sac-fry (possibly due to high levels of fine sediment in spawning gravels). This trap has been discontinued due to lack of funding and personnel. In addition, due to confounding factors (variable water flow, in-trap predation, bed instability during high flow) smolt trap data on sac-fry emergence is not a good sediment monitoring method. Other methodology provides a better indication of stream sediment loading.*

VII. Public Involvement

Northwest Forest Plan
This WQRP is a comprehensive plan for addressing water quality using elements of the Northwest Forest Plan (NWFP). It tiers to and appends the Little River Watershed Analysis. Watershed analyses are a required component of the Aquatic Conservation Strategy (ACS) under the NWFP. The Record of Decision (ROD) for the NWFP was signed in April of 1994, following extensive public review.

Public Land Management Plans
The USFS and BLM are responsible for creating and implementing public land management plans for lands under their jurisdiction. The plans are required to comply with the Clean Water Act and state environmental protection programs. These plans fully address water quality.

The Roseburg Resource Management Plan (RMP) and Record of Decision (ROD) for the BLM Roseburg District were approved on June 2, 1995 after extensive public review. The ROD shows how environmental impacts and other factors were considered in the decision making process. The Governor of Oregon was provided formal opportunity to review the proposed plan. There were no objections from the Governor.

The Land and Resource Management Plan (Forest Plan) for the Umpqua National Forest became effective on October 5, 1990 after extensive public review.

Both agencies issue periodic monitoring reports that describes progress on plan implementation.

Water Quality Restoration Plan
During the planning effort, the BLM referenced this WQRP in quarterly planning updates which are provided to the public. The WQRP was widely distributed for review prior to finalizing. This included review by USFS and BLM regional and Forest/District personnel and the Oregon Department of Environmental Quality. The draft plan was also posted to the Little River AMA website.

Water Quality Management Plan
The Oregon Department of Environmental Quality (DEQ) has lead responsibility for creating Total Maximum Daily Loads (TMDLs) and Water Quality Management Plans (WQMP) to address water quality impaired streams for Oregon. This WQRP will be provided to the DEQ for incorporation into an overall WQMP for the Little River watershed. DEQ has a comprehensive public involvement strategy, which includes informational sessions, mailings, and public hearings. The USFS and BLM will provide support and participate in this public outreach.

VIII. Maintenance of Effort Over Time

The problems leading to water quality limitations and 303(d) listing have accumulated over many decades. Management measures to address these problems will be carried out over an extended period of time. Furthermore, once restorative actions and new practices achieve desired results, continued vigilance will be required to maintain water quality standards.

Northwest Forest Plan and Federal Land Management Plans
The Northwest Forest Plan (NWFP), The Roseburg Resource Management Plan (RMP), and the Land and Resource Management Plan (Forest Plan) for the Umpqua National Forest are ongoing federal land management plans. The NWFP became effective in 1994. Federal law requires the RMP and the Forest Plan. The RMP was implemented in 1995 and covers a period of approximately 10 years or until the next RMP is completed. The Forest Plan became effective in 1990 and also covers a period of approximately 10 years or until the next Forest Plan becomes effective.

Water Quality Restoration Plan
The North Umpqua District Ranger (USFS) and the Swiftwater Field Manager (BLM) working in partnership with the DEQ are responsible for ensuring the WQRP is implemented, reviewed, and amended as needed. This includes the following:

1. Review of the activities of the responsible agencies to determine if implementation is occurring as planned. If it is not, determine the reason and revise the plan as necessary.
2. Promotion of ongoing communication, financial support, and partnerships for implementing priority projects.
3. Continue efforts to explore revised or additional management measures based on results of monitoring activities and other sources of information.
4. As additional information becomes available and techniques are improved, continue to improve and revise cost/benefit estimates.

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APPENDIX D – DEPARTMENT OF AGRICULTURE

TMDL Implementation Plan

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires that a list be developed of all impaired or threatened waters within each state. This list is called the 303(d) list after the section of the CWA that requires it. In Oregon, the Oregon Department of Environmental Quality (ODEQ) is responsible for this work. Section 303(d) also requires that the state establish a Total Maximum Daily Load (TMDL) for any waterbody designated as water quality limited (with a few exceptions, such as in cases where violations are due to natural causes). TMDLs are written plans and analyses established to ensure that waterbodies will attain and maintain water quality standards. The Little River watershed has stream segments listed on the 1998 Oregon 303(d) List for: temperature, pH, sediment, and habitat modification.

TMDLs are proposed for three of the four listed parameters, temperature, pH, and sediment. The TMDLs are applicable to all perennial streams in the Little River watershed. Habitat modification concerns will be addressed in management plans to be developed by designated management agencies (DMAs). As they are not pollutants, TMDLs will not be developed for habitat modification.

Temperature: Load allocations (LAs) for nonpoint sources are based on percent effective shade. Solar radiation has been shown to be the primary human-influenced temperature control. Percent effective shade is the most straightforward parameter to monitor and measure. It is also easily translated into quantifiable water management objectives. Results of simulation modeling using the system potential conditions for effective shading found that not all tributaries or the mainstem are likely to achieve the temperature water quality criterion of 64 degrees F. System potential shading varies depending on stream width, stream orientation and type of vegetation typically found in the region. In the tributaries, the potential effective shading ranges from 84% to 91%. Along the mainstem of Little River, the potential effective shading ranges from 75% to 99%.

There is only one point source discharging to the watershed, at the Wolf Creek Conservation Center. A load allocation in the form of a limit on the maximum temperature of the effluent has been developed. The facility's effluent temperatures have always been less than the limit of the load allocation.

pH: Assessment of the possible causes of high pH in the Little River watershed revealed that nutrient levels are below detection levels at most monitoring locations. The pH problem results from the photosynthetic activity of benthic algae, which are dependent on sunlight and warmth for growth. A strong correlation exists between elevated pH values and stream temperature. Water quality standard attainment for pH is achievable by reducing temperatures. Therefore, load allocations for pH apply the temperature TMDL allocations of percent effective shade, because of the relationship between stream temperature and pH.

Sediment: Sediment delivered to the stream channel above background conditions is attributed mainly to mid-1900's land management practices related to forest harvest in upland and riparian areas and roads utilized to gain access to these areas. The calculated rate of sediment delivery to the stream channel, measured in tons per square mile per year, shows signs of reduction since the most aggressive timber harvest and road building. A load attributed to land management activities has been identified and should be achieved, over time, through hydrologic recovery, controlled management activities in sensitive areas and treatments. TMDL implementation is expected to restore beneficial uses by salmonids and aquatic insects. Load allocations for sediment are expressed in tons of sediment per square mile per year.

Periodic water quality monitoring and use of instream numeric targets will indicate if management actions are attaining desired goals.

Water Quality Management Plan (WQMP): To address these TMDLs, a WQMP has been developed focusing on the following areas:

- Protecting and planting trees along riparian areas;
- Agricultural and forestry runoff management;
- Controlling streambank erosion;
- Planning timber harvests away from sensitive areas to prevent erosion and increased peak flows;
- Repairing and enhancing road/stream crossings to reduce erosion risk;
- Identifying road problems and prioritizing their repair;
- Replacing instream structural components to trap and store sediment.

Management agencies with responsibilities for implementing this TMDL include: Umpqua National Forest, U.S. Bureau of Land Management, Oregon Department of Agriculture and the Oregon Department of Forestry. These agencies have developed water quality management plans to address loadings identified in the 1988 TMDLs and/or are developing those plans now.

TMDL Report: This report presents the Little River TMDLs for public review. It addresses the elements of a TMDL required by the Environmental Protection Agency. These elements include:

- A description of the geographic area to which the TMDL applies;
- Specification of the applicable water quality standards;
- An assessment of the problem, including the extent of deviation of ambient conditions from water quality standards;
- The development of a loading capacity including those based on surrogate measures and including flow assumptions used in developing the TMDL;
- Identification of point sources and non-point sources; development of Waste Load Allocations for point sources and Load Allocations for non-point sources;
- Development of a margin of safety; and
- An evaluation of seasonal variation.

The appendices contain a more detailed description of the studies, computer modeling, references, and data analyses that were done to develop the TMDLs. A Water Quality Management Plan is also presented.

These documents and several public summary documents are available upon request at locations within the Little River watershed and can be found on the DEQ website: http://waterquality.deq.state.or.us/wq/.

Umpqua Basin Agricultural Water Quality Management Administrative Rules:

Umpqua Basin
603-095-0700
Purpose

(1) These rules have been developed to implement a water quality management area plan for the Umpqua Basin Agricultural Water Quality Management Area pursuant to authorities vested in the department through ORS 568.900-568.933 and ORS 561.190 - 561.191, due to a determination by the Environmental Quality Commission to establish Total Maximum Daily Loads and allocate a load to agricultural nonpoint sources. The area plan is known as the Umpqua Basin Agricultural Water Quality Management Area Plan. After adoption of the TMDLs, these rules will be reviewed and modified as needed to provide reasonable assurance that the load allocations for agriculture will be met. Nothing in the Umpqua Basin Agricultural Water Quality Management Area Plan or rules adopted by the department will allow the department to implement this plan or rules in a manner that is in violation of the U. S. Constitution, the Oregon Constitution or other applicable state laws.

(2) It is intended that the Umpqua Basin Agricultural Water Quality Management Area Plan will aid in achieving compliance with these rules through education and promotion of voluntary land management measures.

(3) Failure to comply with any provisions of the Umpqua Basin Agricultural Water Quality Management Area Plan:

> (a) does not constitute a violation of OAR 603-090-0000 to 603-090-0120, or of OAR 603- 095-0010 to OAR 603-095-0760;
>
> (b) is not intended by the Department to be evidence of a violation of any federal, state, or local law by any person.

(4) Nothing in the Umpqua Basin Agricultural Water Quality Management Area Plan shall be used to interpret any requirement of OAR 603-095-0010 to OAR 603-095-0760

Statutory Authority: ORS 561.190-561.191, 568.909
Stats. Implemented: ORS 568.900 - 568.933

603-095-0720
Geographic and Programmatic Scope

(1) The Umpqua Basin includes the drainage area for the South Umpqua, the North Umpqua, the mainstem Umpqua and the Smith River. The physical boundaries of the Umpqua basin are indicated on the map included as Appendix 1 of these rules.

(2) Operational boundaries for the land base under the purview of these rules include all lands within the Umpqua Basin in agricultural use and agricultural and rural lands which are lying idle or on which management has been deferred, with the exception of public lands managed by federal agencies (BLM, USFS and USFWS), and activities which are subject to the Forest Practices Act.

(3) Current productive agricultural use is not required for the provisions of these rules to apply. For example, highly erodible lands with no present active use are within the purview of these rules.

(4) The provisions and requirements outlined in these rules may be adopted by reference by Designated Management Agencies with appropriate authority and responsibilities in other geographic areas of the Umpqua Basin.

(5) For lands in agricultural use within other Designated Management Agencies' or state agency jurisdictions, the department and the appropriate Local Management Agency shall work with these Designated Management Agencies to assure that provisions of these rules apply, and to assure that duplication of any services provided or fees assessed does not occur.

Statutory Authority: ORS 561.190-561.191, 568.909, and 568.927
Stats. Implemented: ORS 568.900 - 568.933
Umpqua Basin Agricultural Water Quality Management Area Rules January 10, 2001 Page 1

APPENDIX E – DEPARTMENT OF FORESTRY

Implementation Plan for

Non-Federal Forest Lands

Non-Federal Forest Lands

The purpose and goals of Oregon's Water Protection Rules (OAR 629-635-100) include protecting, maintaining, and improving the functions and values of streams, lakes, wetlands, and riparian management areas. Best management practices (BMPs) in the Oregon Forest Practices Act (FPA), including riparian zone protection measures and a host of other measures described below, are the mechanism for meeting State Water Quality Standards (WQS). There is a substantial body of scientific research and monitoring that supports an underlying assumption of the FPA, that maintaining riparian processes and functions is critical for water quality and fish and wildlife habitat. These riparian processes and functions include: Shade for stream temperature and for riparian species; large wood delivery to streams and riparian areas; leaf and other organic matter inputs; riparian microclimate regulation; sediment trapping; soil moisture and temperature maintenance; providing aquatic and riparian species dependent habitat; and nutrient and mineral cycling. The FPA provides a broad array of water quality benefits and contributes to meeting water quality standards for water quality parameters such as temperature, sediment, phosphorus, dissolved oxygen, nutrients, aquatic habitat and others.

Currently, many streams within the Little River Watershed significantly exceed the WQS's for the parameters of concern. The water quality impairment(s) in the Little River Watershed clearly do not result solely from current forestry activities. Agricultural areas contribute significantly to water quality impairment within the basin. It is also important to note that historic forest practices such as splash dam activities, use of log puncheon culverts, abandoned forest roads, and the widespread removal of wood from streams may continue to influence current stream conditions and riparian functions. In addition, current forest practices occur on forest lands that simultaneously support non-forestry land uses that can affect water quality, such as recreation, grazing and public access roads.

Water quality parameters are influenced in a number of ways. For example, it is recognized that increasing the level of riparian vegetation retained along forested reaches of these streams reduces solar loading, potentially preventing a substantial amount of stream heating. While providing high levels of shade to streams is an important aspect of meeting instream temperature standards it needs to be considered within the context of past management, stream morphology and flows, groundwater influences, site-productivity, insects, fire, and other disturbance mechanisms that vary in time and space across the landscape.

The amount of sediment reaching streams can also affect water quality. For example, it is recognized that, proper road construction and culvert placement, good road maintenance, appropriate road surfacing, locating side-cast and soil waste materials in stable locations, properly placing and removing temporary stream crossings, establishing appropriate water-bars on skid trails, using appropriate harvesting systems and techniques, proper site preparation (including slash disposal), among other sound forestry practices, can reduce or eliminate sediment from entering streams. The FPA deals with these and other forest activities.

As described below, ODF and DEQ are involved in several statewide efforts to analyze the existing FPA measures and to better define the relationship between TMDL load allocations and the FPA measures designed to protect water quality. How water quality parameters are affected, as established through the TMDL process as well as other monitoring data, will be an important part of the body of information used in determining the adequacy of the FPA.

Forest practices on non-federal land in Oregon are regulated under the FPA and implemented through administrative rules that are administered by the Oregon Department of Forestry (ODF). The Oregon Board of Forestry (BOF), in consultation with the Environmental Quality Commission (EQC), establish BMPs and other rules to ensure that, to the extent practicable, nonpoint source (NPS) pollution resulting from forest operations does not impair the attainment of water quality standards.

With respect to the temperature standard, surface water temperature management plans are required according to OAR 340-041-0026 when temperature criteria are exceeded and the waterbody is designated as water-quality limited under Section 303(d) of the Clean Water Act. In the case of state and private forest lands, OAR 340-041-0120 identifies the FPA rules as the surface water management plan for forestry activities. The DEQ recognizes (through a Memorandum of Understanding with ODF) that the FPA provide the Best Management Practices (BMPs) for forest activities on non-federal forest land in Oregon.

ODF and DEQ statutes and rules also include provisions for adaptive management that provide for revisions to FPA practices where necessary to meet water quality standards. These provisions are described in ORS 527.710, ORS 527.765, ORS 183.310, OAR 340-041-0026, OAR 629-635-110, and OAR 340-041-0120. Current adaptive management efforts under several of the above statutes and rules are described in more detail following the discussion below on the roles of the BOF and EQC in developing BMPs that will achieve water quality standards.

ORS 527.765 Best management practices to maintain water quality.

> **(1) The State Board of Forestry shall establish best management practices and other rules applying to forest practices as necessary to insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forest lands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state. Such best management practices shall consist of forest practices rules adopted to prevent or reduce pollution of waters of the state. Factors to be considered by the board in establishing best management practices shall include, where applicable, but not be limited to:**
>
> (a) Beneficial uses of waters potentially impacted;
> (b) The effects of past forest practices on beneficial uses of water;
> (c) Appropriate practices employed by other forest managers;
> (d) Technical, economic and institutional feasibility; and
> (e) Natural variations in geomorphology and hydrology.

ORS 527.770 Good faith compliance with best management practices not violation of water quality standards; subsequent enforcement of standards.
A forest operator conducting, or in good faith proposing to conduct, operations in accordance with best management practices currently in effect shall not be considered in violation of any water quality standards. When the State Board of Forestry adopts new

best management practices and other rules applying to forest operations, such rules shall apply to all current or proposed forest operations upon their effective dates.

There are currently extensive statutes and administrative rules that regulate forest management activities in the Little River Watershed, which address the key water quality issues of stream temperatures, riparian aquatic functions, and sediment dynamics. The following is a list of specific administrative rules describing the purpose and goals of the FPA towards the achievement and maintenance of water quality standards established by the EQC.

OAR 629-635-100 - Water Protection Rules; Purpose and Goals

(3) The purpose of the water protection rules is to protect, maintain and, where appropriate, improve the functions and values of streams, lakes, wetlands, and riparian management areas. These functions and values include water quality, hydrologic functions, the growing and harvesting of trees, and fish and wildlife resources.

(4) The water protection rules include general vegetation retention prescriptions for streams, lakes and wetlands that apply where current vegetation conditions within the riparian management area have or are likely to develop characteristics of mature forest stands in a "timely manner." Landowners are encouraged to manage stands within riparian management areas in order to grow trees in excess of what must be retained so that the excess may be harvested.

(5) The water protection rules also include alternative vegetation retention prescriptions for streams to allow incentives for operators to actively manage vegetation where existing vegetation conditions are not likely to develop characteristics of mature conifer forest stands in a "timely manner."

(6) OARs 629-640-400 and 629-645-020 allow an operator to propose site-specific prescriptions for sites where specific evaluation of vegetation within a riparian management area and/or the condition of the water of the state is used to identify the appropriate practices for achieving the vegetation and protection goals.

(7) The overall goal of the water protection rules is to provide resource protection during operations adjacent to and within streams, lakes, wetlands and riparian management areas so that, while continuing to grow and harvest trees, the protection goals for fish, wildlife, and water quality are met.

- **(a) The protection goal for water quality (as prescribed in ORS 527.765) is to ensure through the described forest practices that, to the maximum extent practicable, nonpoint source discharges of pollutants resulting from forest operations do not impair the achievement and maintenance of the water quality standards.**
- (b) The protection goal for fish is to establish and retain vegetation consistent with the vegetation retention objectives described in OAR 629-640-000 (streams), OAR 629-645-000 (significant wetlands), and OAR 629-650-000 (lakes) that will maintain water quality and provide aquatic habitat components and functions such as shade, large woody debris, and nutrients.

OAR 629-640-000 - Vegetation Retention Goals for Streams; Desired Future Conditions

(1) The purpose of this rule is to describe how the vegetation retention measures for

streams were determined, their purpose and how the measures are implemented. The vegetation retention requirements for streams described in OAR 629-640-100 through OAR 629-640-400 are designed to produced desired future conditions for the wide range of stand types, channel conditions, and disturbance regimes that exist throughout forest lands in Oregon.

(2) The desired future condition for streamside areas along fish use streams is to grow and retain vegetation so that, over time, average conditions across the landscape become similar to those of mature streamside stands. Oregon has a tremendous diversity of forest tree species growing along waters of the state and the age of mature streamside stands varies by species. Mature streamside stands are often dominated by conifer trees. For many conifer stands, mature stands occur between 80 and 200 years of stand age. Hardwood stands and some conifer stands may become mature at an earlier age. Mature stands provide ample shade over the channel, an abundance of large woody debris in the channel, channel-influencing root masses along the edge of the high water level, snags, and regular inputs of nutrients through litter fall.

(3) The rule standards for desired future conditions for fish use streams were developed by estimating the conifer basal area for average unmanaged mature streamside stands (at age 120) for each geographic region. This was done by using normal conifer yield tables for the average upland stand in the geographic region, and then adjusting the basal area for the effects of riparian influences on stocking, growth and mortality or by using available streamside stand data for mature stands.

(4) The desired future condition for streamside areas that do not have fish use is to have sufficient streamside vegetation to support the functions and processes that are important to downstream fish use waters and domestic water use and to supplement wildlife habitat across the landscape. Such functions and processes include: maintenance of cool water temperature and other water quality parameters; influences on sediment production and bank stability; additions of nutrients and large conifer organic debris; and provision of snags, cover, and trees for wildlife.

(5) The rule standards for desired future conditions for streams that do not have fish use were developed in a manner similar to fish use streams. In calculating the rule standards, other factors used in developing the desired future condition for large streams without fish use and all medium and small streams included the effects of trees regenerated in the riparian management area during the next rotation and desired levels of instream large woody debris.

(6) For streamside areas where the native tree community would be conifer dominated stands, mature streamside conditions are achieved by retaining a sufficient amount of conifers next to large and medium sized fish use streams at the time of harvest, so that halfway through the next rotation or period between harvest entries, the conifer basal area and density is similar to mature unmanaged conifer stands. In calculating the rule standards, a rotation age of 50 years was assumed for even-aged management and a period between entries of 25 years was assumed for uneven-aged management. The long-term maintenance of streamside conifer stands is likely to require incentives to landowners to manage

streamside areas so that conifer reforestation occurs to replace older conifers over time.

(7) Conifer basal area and density targets to produce mature stand conditions over time are outlined in the general vegetation retention prescriptions. In order to ensure compliance with state water quality standards, these rules include requirements to retain all trees within 20 feet and understory vegetation within 10 feet of the high water level of specified channels to provide shade.

(8) For streamside areas where the native tree community would be hardwood-dominated stands, mature streamside conditions are achieved by retaining sufficient hardwood trees. As early successional species, the long-term maintenance of hardwood streamside stands will in some cases require managed harvest using site specific vegetation retention prescriptions so that reforestation occurs to replace older trees. In order to ensure compliance with state water quality standards, these rules include requirements in the general vegetation retention prescription to retain all trees within 20 feet and understory vegetation within 10 feet of the high water level of specified channels to provide shade.

(9) In many cases the desired future condition for streams can be achieved by applying the general vegetation retention prescriptions, as described in OAR 629-640-100 and OAR 629-640-200. In other cases, the existing streamside vegetation may be incapable of developing into the future desired conditions in a "timely manner." In this case, the operator can apply an alternative vegetation retention prescription described in OAR 629-640-300 or develop a site specific vegetation retention prescription described in OAR 629-640-400. For the purposes of the water protection rules, "in a timely manner" means that the trees within the riparian management area will meet or exceed the applicable basal area target or vegetation retention goal during the period of the next harvest entry that would be normal for the site. This will be 50 years for many sites.

(10) Where the native tree community would be conifer dominant stands, but due to historical events the stand has become dominated by hardwoods, in particular, red alder, disturbance is allowed to produce conditions suitable for the re-establishment of conifer. In this and other situations where the existing streamside vegetation is incapable of developing characteristics of a mature streamside stand in a "timely manner," the desired action is to manipulate the streamside area and woody debris levels at the time of harvest (through an alternative vegetation retention prescription or site specific vegetation retention prescription) to attain such characteristics more quickly.

The Water Protection Rules are an important component of the rules that are designed to achieve and maintain water quality standards. The rules identify seven geographic regions and distinguishes between streams, lakes, and wetlands. The rules further distinguish each stream by size and type. Stream size is distinguished as small, medium, or large, based on average annual flow. Stream type is distinguished as fish use, domestic use, or neither.

Generally, no tree harvesting is allowed within 20 feet of all fish bearing, all domestic-use, and all other medium and large streams unless stand restoration is needed. In addition, all snags and downed wood must be retained in every riparian management area. Provisions governing vegetation retention are designed to encourage conifer restoration on riparian forest land that is not currently in the desired conifer condition. Future supplies of conifer on these sites are deemed desirable to support stream functions and to provide fish and wildlife habitat. The rules provide incentives for landowners to place large wood in streams to immediately enhance fish habitat. Other alternatives are provided to address site-specific conditions and large-scale catastrophic events.

The goal for managing riparian forests along fish-use streams is to grow and retain vegetation so that, over time, average conditions across the riparian landscape become similar to those of mature unmanaged riparian stands. This goal is based on the following considerations:

(1) Mature riparian stands can supply large, persistent woody debris necessary to maintain adequate fish habitat. A shortage of large wood currently exists in streams on non-federal forest lands due to historic practices and a wide distribution of young, second growth forests. For most streams, mature riparian stands are able to provide more of the functions and inputs of large wood than are provided by young second-growth trees.

(2) Historically, riparian forests were periodically disturbed by wildfire, windstorms, floods, and disease. These forests were also impacted by wildlife such as beaver, deer, and elk. These disturbances maintained a forest landscape comprised of riparian stands of all ages ranging from early successional to old growth. At any given time, however, it is likely that a significant proportion of the riparian areas supported forests of mature age classes. This distribution of mature riparian forests supported a supply of large, persistent woody debris that was important in maintaining quality fish habitat.

The overall goals of the riparian vegetation retention rules along Type N and Type D streams are the following:

- Grow and retain vegetation sufficient to support the functions and processes that are important to downstream waters that have fish;
- Maintain the quality of domestic water; and
- Supplement wildlife habitat across the landscape.

These streams have reduced Riparian Management Area (RMA) widths and reduced basal area retention requirements as compared to similar sized Type F streams (Table 1). In the design of the rules this was judged appropriate based on a few assumptions. First, it was assumed that the amount of large wood entering Type N and D channels over time was not as important for maintaining fish populations within a given stream reach. And second, it was assumed that the future stand could provide some level of "functional" wood over time in terms of nutrient inputs and sediment storage. The validity of these assumptions needs to be evaluated over time through monitoring.

Table 1. Riparian Management Area Widths for Streams of Various Sizes and Beneficial Uses (OAR 629-635-310)

	Type F	Type D	Type N
LARGE	100 feet	70 feet	70 feet
MEDIUM	70 feet	50 feet	50 feet
SMALL	50 feet	20 feet	Apply specified water quality protection measures, and see OAR 629-640-200

For all streams that require an RMA, basal area targets are established that are used for any type of management within the RMA. These targets were determined based on the data that was available at the time, with the expectation that these targets could be achieved on the ground. There is also a minimum tree number requirement of 40 trees per 1000 feet along large streams (11-inch minimum diameter at breast height), and 30 trees per 1000 feet along medium streams (8-inch minimum diameter at breast height). The specific levels of large wood inputs that the rules are designed to achieve are based on the stream size and type. The biological and physical characteristics specific to a given stream are taken into account in determining the quantity and quality of large wood that is functional for that stream. Given the potential large wood that is functional for a given stream, a combination of basal area targets, minimum tree retention, buffer widths, and future regenerated stands and ingrowth are used to achieve the appropriate large wood inputs and effective shade for a given stream.

The expectation is that these vegetation retention standards will be sufficient towards maintaining stream temperatures that are within the range of natural variability. In the design of the Water Protection Rules shade data was gathered for 40 small non-fish-bearing streams to determine the shade recovery rates after harvesting. One to two years after harvest, 55 percent of these streams were at or above pre-harvest shade levels due to understory vegetation regrowth. Most of these streams had a bankfull width averaging less than six feet, and most shade was provided by shrubs and grasses within 10 feet of the bank. Since 1991 there has also been a 120-acre limit on a single clearcut size, which is likely to result in a scattering of harvested area across a watershed over time. In the development of the rules it was assumed that this combined with the relative rapid shade recovery along smaller non-fish-bearing streams would be adequate in protecting stream temperatures and reduce possible cumulative effects. For fish bearing streams it is assumed that a 20-foot no-harvest area, combined with the tree retention requirements for the rest of the RMA, will be adequate to maintain shade levels necessary to achieve stream temperature standards. The monitoring program is currently collecting data to test these assumptions, evaluate the effectiveness of the rules, and evaluate whether or not water quality standards for temperature are being achieved.

In terms of sediment issues specific to forest roads, there are BMPs within the FPA specifically designed to regulate road design, construction and maintenance. The bulk of the BMPs are directed at minimizing sediment delivery to channels. The primary goals of the road rules are to: (1) protect the water quality of streams, lakes, and wetlands; (2) protect fish and wildlife habitat; and (3) protect forest productivity.

The Board of Forestry revised several BMPs related to road design when the new Water Protection Rules were adopted in the fall of 1994. Significant changes made to the road construction rules include the following:

- The requirement for operators not to locate roads in riparian management areas, flood plains, or wetlands unless all alternative locations would result in greater resource damage.
- The requirement for operators to design stream crossings to both minimize fill size and minimize excavation of slopes near the channel. A mandatory written plan is required for stream crossing fills over 15 feet deep.
- The requirement to design stream crossing structures for the 50-year flow with no ponding, rather than the 25-year storm with no specification of allowable ponding.
- The requirement that stream crossing structures be passable by juvenile fish as well as adult fish.
- The requirement that fish must be able to access side channels.
- The requirement that stream structures constructed under these rules must be maintained for fish passage.

In determining the location of a new road, operators are required to avoid steep slopes, slides and areas next to channels or in wetlands to the extent possible. Existing roads should be used when possible, and stream crossings should be used only when essential. The design of the road grade must vary to fit the local terrain and the road width must be minimized. The operator must also follow specific guidelines for stream-crossing structures (listed above). Cross-drainage structures must be designed to divert water away from channels so that runoff intercepted by the road is dispersed onto the hillslope before reaching a channel. The specific method used is up to the operator, but the end result should be the dispersal of water running off of the road and the filtering of fine sediment before the water reaches waters of the state.

Construction and maintenance activities should be done during low water periods and when soils are relatively dry. Excavated materials must be placed where there is minimal risk of those materials entering waters of the state, and erodible surfaces must be stabilized. Landings must be built away from streams, wetlands and steep slopes.

Road maintenance is required on all active and inactive roads. Regardless of when a road was constructed, if the road has been used as part of an active operation after 1972, it is subject to all maintenance requirements within the current rules. Culverts must be kept open, and surface road drainage and adequate filtering of fine sediment must be maintained. If the road surface becomes unstable or if there is a significant risk of sediment running off of the road surface and entering the stream, road activity must be halted and the erodible area must be stabilized. Abandoned roads constructed prior to 1972 <u>and</u> not used for forest management since that time are not subject to Forest Practices regulatory authority.

All roads in use since 1972 must either be maintained or vacated by the operator. Vacated roads must be effectively barricaded and self-maintaining, in terms of diverting water away from streams and off of the former road surface, where erosion will remain unlikely. Methods for vacating roads include pulling stream-crossing fills, pulling steep side cast fills, and cross ditching. It is up to the landowner to choose between vacating a road and maintaining a road. If a road is not vacated, the operator is required to maintain the road under the current rules whether it is active or inactive, however they are not required to bring the design up to current standards outside of the normal maintenance and repair schedule.

The ODF has a monitoring program that is currently coordinating separate projects to monitor the effectiveness of the forest practice rules with regard to landslides, riparian function, stream temperature, chemical applications, sediment from roads, BMP compliance, and shade. The results from some of these projects have been released in the form of final reports and other projects will have final reports available in the spring of 2000, 2001 and beyond.

Voluntary measures are currently being implemented across the state under the Oregon Plan for Salmon and Watersheds (OPSW) to address water quality protection. These measures are designed to supplement the conifer stocking within riparian areas, increase large wood inputs to streams, and provide for additional shade. This is accomplished during harvest operations by (1) placing appropriate sized large wood within streams that meet parameters of gradient, width and existing wood in the channel; and (2) relocating in-unit leave trees in priority areas[1] to maximize their benefit to salmonids while recognizing operational constraints, other wildlife needs, and specific landowner concerns.

The measures include the following:

ODF 8S: Riparian Conifer Restoration

Forest practice rules have been developed to allow and provide incentives for the restoration of conifer forests along hardwood-dominated RMAs where conifers historically were present. This process enables sites capable of growing conifers to contribute conifer LWD in a timelier manner. This process will be modified to require an additional review process before the implementation of conifer restoration within core areas.

ODF 19S: Additional Conifer Retention along Fish-Bearing Streams in Core Areas

This measure retains more conifers in RMAs by limiting harvest activities to 25 percent of the conifer basal area above the standard target. This measure is only applied to RMAs containing a conifer basal area that is greater than the standard target.

ODF 20S: Limited RMA for Small Type N Streams in Core Areas

This measure provides limited 20 foot RMAs along all perennial or intermittent small Type N streams for the purpose of retaining snags and downed wood.

ODF 21S: Active Placement of large wood during Forest Operations

This measure provides a more aggressive and comprehensive program for placing large wood in streams currently deficient of large wood. Placement of large wood is accomplished following existing ODF/ODFW placement guidelines and determining the need for large wood placement is based upon a site-specific stream survey.

ODF 22S: 25 Percent In-unit Leave Tree Placement and Additional Voluntary Retention

This measure has one non-voluntary component and two voluntary components:

[1] The Executive Order replaced the concept of “core areas” with “priority areas”. See (1)(f) of the Executive Order (p.5).

1) The State Forester, under statutory authority, will direct operators to place 25 percent of in-unit leave trees in or adjacent to riparian management areas on Type F and D streams.
2) The operator voluntarily locates the additional 75 percent in-unit leave trees along Type N, D or F streams, and
3) The State Forester requests the conifer component be increased to 75 percent from 50 percent.

ODF 61S: Analysis of "Rack" Concept for Debris Flows

OFIC members will conduct surveys to determine the feasibility and value of retaining trees along small type N streams with a high probability of debris flow in a "rack" just above the confluence with a Type F stream. The rack would extend from the RMA along the Type F stream up the Type N stream some distance for the purpose of retaining trees that have a high likelihood of delivery to the Type F stream.

ODF 62S: Voluntary No-Harvest Riparian Management Areas

Establishes a system to report and track, on a site-specific basis, when landowners voluntarily take the opportunity to retain no-harvest RMAs.

The voluntary management measures are implemented within priority areas. Several of the measures utilize in-unit leave trees and are applied in a “menu” approach to the extent in-unit leave trees are available to maximize their value to the restoration of salmonid habitat. The choice of menu measures is at the discretion of the landowner, but one or more of the measures is selected.

The measures can be described as either active restoration measures, or passive restoration measures that provide long-term large wood recruitment. Voluntary measures ODF 8S and 21S are active restoration activities. ODF 8 restores hardwood-dominated riparian areas back to a conifer-dominated condition, where appropriate, using a site-specific plan. Site-specific plans require additional consultation with the ODFW to minimize potential damage to the resource. They often result in conditions that are more protective of the resources than would occur without the site-specific plan. ODF 21S addresses large wood placement if stream surveys determine there is a need. Measures ODF 19S, 20S, 22S, and 62S provide future large wood recruitment through additional riparian protection. This additional protection is accomplished by retaining in-unit leave trees, snags, and downed wood within and along RMAs, and by changing the ratio of in-unit leave trees to 75 percent conifer.

The following application priority has been developed for OPSW voluntary measures for harvest units containing more than one stream type. The list establishes the general priority for placement of in-unit leave trees.

1) Small and medium Type F streams.
2) Non-fish bearing streams (Type D or Type N), especially small low-order headwater stream channels, that may affect downstream water temperatures and the supply of large wood in priority area streams.
3) Streams identified as having a water temperature problem in the DEQ 303(d) list of water quality limited waterbodies, or as evidenced by other available water temperature data; especially reaches where the additional trees would increase the level of aquatic shade.

4) Potentially unstable slopes where slope failure could deliver large wood.
5) Large Type F streams, especially where low gradient, wide floodplains exist with multiple, braided meandering channels.
6) Significant wetlands and stream-associated wetlands, especially estuaries and beaver pond complexes, associated with a salmon core area stream.

The Oregon Plan also has voluntary measures addressing sediment issues related to forest roads. Many forest roads built prior to the development of the FPA or prior to the current BMPs continue to pose increased risk to fish habitat. Industrial forest landowners and state forest lands are currently implementing the Road Hazard Identification and Risk Reduction Project, measures ODF 1S and ODF 2S, to identify risks to salmon from roads and address those risks. The purposes of this project are:

1. Implement a systematic process to identify road-related risks to salmon and steelhead recovery.
2. Establish priorities for problem solution.
3. Implement actions to reduce road related risks.

The Road Hazard Identification and Risk Reduction Project is a major element of the Oregon Plan. The two major field elements of this project are (1) the surveying of roads using the Forest Road Hazard Inventory Protocol, and (2) the repairing of problem sites identified through the protocol. Road repairs conducted as a result of this project include improving fish passage, reducing washout potential, reducing landslide potential, and reducing the delivery of surface erosion to streams.

Roads assessed by this project include all roads on Oregon Forest Industry Council member forest land, plus some other industrial and non-industrial forest land, regardless of when they were constructed. Industrial forest landowners have estimated spending approximately $13 million a year, or $130 million over the next 10 years, on this project for the coastal ESUs alone. However, the effort is not limited to nor bound by this funding estimate. Funding for the implementation for this measure within the other ESUs will be reflective of road problems found.

Under ODF 2S, the State Forest Lands program has spent over $2.5 million during the last biennium (1997-1999) for the restoration of roads, replacement of culverts and other stream crossing structures damaged by the 1996 storm. State Forest Lands are also proposing to spend an additional $2.5 million dollars in each of the next two biennia to improve roads, including stream crossing structures. This effort will upgrade approximately 130 miles of road in each biennium.

In addition to ODF 1S & 2S, there are additional measures under the Oregon Plan that address road management concerns:

ODF 16S Evaluation of the Adequacy of Fish Passage Criteria: Establish that the criteria and guidelines used for the design of stream crossing structures pass fish as intended under the goal.

ODF 34S - Improve Fish Passage BMPs on Stream Crossing Structures: Ensure that all new stream crossing structures on forest land installed or replaced after the fall of 1994 will pass both adult and juvenile fish upstream and down stream.

Adaptive Management Process

By statute, forest operators conducting operations in accordance with the BMPs are considered to be in compliance with Oregon's water quality standards. The 1994 Water Protection Rules were adopted with the approval of the Environmental Quality Commission as not violating water quality standards. However, there are several provisions within the FPA and rules that require adaptive management.

The ODF is currently in the process of reviewing the effectiveness of the forest practice rules. In January of this year the Governor of Oregon signed Executive Order no. EO 99-01 that directed the Oregon Board of Forestry, with the assistance of an advisory committee, to determine to what extent changes to forest practices are needed to meet state water quality standards and protect and restore salmonids. The committee is directed to consider both regulatory and non-regulatory approaches to water quality protection. To carry out this charge, an ad hoc advisory committee is in the process of developing four separate issue papers on the following topics:

- Fish passage restoration and water classification
- Forest roads
- Riparian functions
- Landslides

The committee represents diverse interests, including environmental, industrial, non-industrial, county, and public advocates. In addition to ODF technical staff, the Oregon Department of Environmental Quality (DEQ) and Oregon Department of Fish and Wildlife (ODFW) have technical staff participating in the process. The committee expects to make recommendations to the Board of Forestry in early 2000. The Board will then consider the recommendations in determining whether revisions to the FPA and additional voluntary approaches are necessary consistent with ORS 527.710.

As the designated management agency (DMA) for water quality management on nonfederal forest lands, ODF is also working with the DEQ through a memorandum of understanding (MOU) signed in June of 1998. This MOU was designed to improve the coordination between the ODF and the DEQ in evaluating and proposing possible changes to the forest practice rules as part of the Total Maximum Daily Load process. The purpose of the MOU is also to guide coordination between the ODF and DEQ regarding water quality limited streams on the 303d list. An evaluation of rule adequacy will be conducted (also referred to as a "sufficiency analysis") through a water quality parameter by parameter analysis. This statewide demonstration of forest practices rule effectiveness in the protection of water quality will address the following specific parameters and will be conducted in the following order[2]:

1) Temperature (estimated draft report target completion date Spring, 2000)
2) Sediment and turbidity (estimated date Fall, 2000)
3) Aquatic habitat modification (estimated date Spring, 2001)
4) Bio-criteria (estimated date Fall, 2001)
5) Other parameters (estimated date Spring, 2002)

[2] The estimated completion dates listed here differ from those dates listed in the MOU. Due to unforeseen circumstances the DEQ and ODF have agreed to revise the dates.

These sufficiency analyses will be reviewed by peers and other interested parties prior to final release. The analyses will be designed to provide background information and techniques for watershed-based assessments of BMP effectiveness and water quality assessments for watershed with forest and mixed land uses. Once the sufficiency analyses are completed, they will be used as a coarse screen for common elements applicable to each individual TMDL to determine if forest practices are contributing to water quality impairment within a given watershed and to support the adaptive management process.

There may be circumstances unique to a watershed or information generated outside of the statewide sufficiency process that need to be considered to adequately evaluate the effectiveness of the BMPs in meeting water quality standards. Information from the TMDL, ad hoc committee process, ODF Water Protection Rule effectiveness monitoring program, and other relevant sources may address circumstances or issues not addressed by the statewide sufficiency process. This information will also be considered in making the FPA sufficiency determination. ODF and DEQ will share their understanding of whether water quality impairment is due to current forest practices or the long-term legacy of historic forest management practices and/or other practices. The two agencies will then work together and use their determinations to figure out which condition exists (a, b, c, or d in the MOU). The MOU describes the appropriate response depending on which condition exists.

Currently ODF and DEQ do not have adequate data to make a collective determination on the sufficiency of the current FPA BMPs in meeting water quality standards within the Little River Watershed. This situation most closely resembles the scenario described under condition c of the ODF/DEQ MOU. Therefore, the current BMPs will remain as the forestry component of the TMDL. The draft versions of the statewide FPA sufficiency analyses for the various water quality parameters will be completed as noted above. The proposed Little River TMDLs will be completed in September, 2001. Data from an ODF/DEQ shade study will be collected over the summer of 1999 and a final report will be completed in the summer of 2000. Information from the ad hoc committee advisory process may be available by summer of 2000. Information from these efforts, along with other relevant information provided by the DEQ, will be considered in reaching a determination on whether the existing FPA BMPs meet water quality standards within the Umpqua Basin.

The above adaptive management process may result in findings that indicate changes are needed to the current forest practice rules to protect water quality. Any rule making that occurs must comply with the standards articulated under ORS 527.714(5). This statute requires, among other things, that regulatory and non-regulatory alternatives have been considered and that the benefits provided by a new rule are in proportion to the degree that existing forest practices contribute to the overall resource concern.

APPENDIX F – OREGON DEPARTMENT OF TRANSPORTATION

TMDL IMPLEMENTATION PLAN

The Oregon Department of Transportation (ODOT) plan addresses the requirements of a Total Maximum Daily Load (TMDL) allocation for pollutants associated with the ODOT system. This statewide approach for an ODOT TMDL watershed management plan would address specific pollutants, but not specific watersheds. Instead, this plan would demonstrate how ODOT incorporates water quality into project development, construction, and operations and maintenance of the state and federal transportation system, thereby meeting the elements of the National Pollutant Discharge Elimination System (NPDES) program, and the TMDL requirements.

ODOT has partnered with DEQ in the development of several watershed management plans. By presenting a single, statewide, management plan, ODOT:

Streamlines the evaluation and approval process for the watershed management plans
Provides consistency to the ODOT highway management practices in all TMDL watersheds.
Eliminates duplicative paperwork and staff time developing and participating in the numerous TMDL management plans.

Temperature and sediment are the primary concerns for pollutants associated with ODOT systems that impair the waters of the state. DEQ is still in the process of developing the TMDL water bodies and determining pollutant levels that limit their beneficial uses. As TMDL allocations are established by watershed, rather than by pollutants, ODOT is aware that individual watersheds may have pollutants that may require additional consideration as part of the ODOT watershed management plan. When these circumstances arise, ODOT will work with DEQ to incorporate these concerns into the statewide plan.

In the Little River Watershed, the only road under ODOT jurisdiction is the bridge over Little River in Glide. Thus, rather than detailing the entire ODOT statewide plan, the following are the provisions which will be relevant to the Little River Watershed.

ODOT Limitations

The primary mission of ODOT is to provide a safe and effective transportation system, while balancing the requirements of environmental laws. ODOT is a dedicated funding agency, restricted by the Oregon Constitution in its legal authority and use of resources in managing and operating the state and federal highway system.

On June 9, 2000, ODOT received an NPDES permit from DEQ that covers all new and existing discharges of stormwater from the Municipal Separated Storm Sewer associated with the ODOT owned and maintained facilities and properties located within the highway right of way and maintenance facilities for all basins in Oregon. This permit required the development of a statewide ODOT stormwater management plan.

ODOT Programs

ODOT established a Clean Water program in 1994 that works to develop tools and processes that will minimize the potential negative impacts of activities associated with ODOT facilities on Oregon's water resources. The ODOT Clean Water program is based on developing and implementing Best Management Practices (BMPs) for construction and maintenance activities. ODOT has developed, or is developing the following documents, best management practices, or reviews, that reduce sediment and temperature impacts:

- **ODOT Routine Road Maintenance Water Quality and Habitat Guide, Best Management Practices, July 1999 (ESA 4(d) Rule)**

ODOT has worked with National Marine Fisheries Service (NMFS) and Oregon Department of Fish and Wildlife (ODFW) to develop Best Management Practices (BMPs) that minimize negative environmental impacts of routine road maintenance activities on fish habitat and water quality. The National Marine Fisheries Service has determined that routine road maintenance, performed under the above mentioned guide, does not constitute a 'take' of anadromous species listed under the federal Endangered Species Act, and therefore additional federal oversight is not required. This determination has been finalized as part of the Federal Register, Volume 65, Number 132, dated Monday, July 10, 2000, pages 42471-42472. In addition, the Oregon Department of Fish and Wildlife has determined that the guide and BMPs are adequate to protect habitat during routine maintenance activities.

- **NPDES Municipal Separated Storm Sewer System (MS4) Permit**

ODOT worked with DEQ to develop a statewide NPDES MS4 permit and stormwater management program that reduces pollutant loads in the ODOT stormwater system. The permit was issued to ODOT on June 9, 2000.

- **NPDES 1200CA Permit**

ODOT has developed an extensive erosion control program that is implemented on all ODOT construction projects. The program addresses erosion and works to keep sediment loads in surface waters to a minimum. ODOT currently holds 5 regional permits that cover highway construction.

- **Erosion and Sediment Control Manual**

ODOT Geotechnical/Hydraulic staff has developed erosion and sediment control manuals and training for construction and maintenance personnel. Included in the manual are designs for different types of erosion control measures.

- **National Environmental Policy Act (NEPA) Reviews**

ODOT is an agent of the Federal Highway Administration, consequently, ODOT must meet NEPA requirements during project development. Included in the project development process are reviews to avoid, minimize and mitigate project impacts to natural resources, including wetlands and waters of the state.

ODOT TMDL Pollutants

ODOT and DEQ have identified temperature and sediment as the primary TMDL pollutants of concern associated with highways. While DEQ may identify other TMDL pollutants within the watershed, many historical pollutants, or pollutants not associated with ODOT activities, are outside the control or responsibility of ODOT. In some circumstances, such as historical pollutants within the right of way, it is expected that ODOT will control these pollutants through the best management practices associated with sediment control. ODOT is expecting that by controlling sediment load these TMDL pollutants will be controlled. Research has indicated that controlling sediment also controls heavy metals, oils and grease, and other pollutants.

Proposed Management Measures tied to attainment of TMDLs.

- **The ODOT Routine Road Maintenance Water Quality and Habitat Guide, Best Management Practices, July 1999- addresses sediment and temperature TMDL.**

ODOT programs are adaptive and are expected to change as new information becomes available. ODOT will continue to work with the DEQ, NMFS, USFWS, and ODFW in best management practices, research opportunities, training, etc. The ODOT program meets the requirements of the TMDL management plans, and will be attached as appropriate to individual watershed plans.